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Typical and critical traffic situations with small electric delivery vehicles – indications for future Automated Delivery Vehicles

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Cover image: Johan Stjerneus, Source: Postnord media bank

Abstract

This study investigated what typical traffic situations drivers of small manual delivery vehicles (MDV) are facing during their daily routes and how they handle these, sometimes critical, traffic situations. The purpose was to get an understanding of what challenges future automated delivery vehicles (ADV) may encounter and need to manage. Nine drivers of MDVs at one of Postnord's terminals in Gothenburg, Sweden, were interviewed about their daily working tasks, their experiences of typical and critical situations and how they handle these situations.

The interviews showed that many potentially critical situations were related the MDV's relative slow speed (max 45 km/h). They could not always keep the same speed as other vehicles, which resulted in other vehicles driving closely behind the MDV and overtaking the MDV in narrow and busy roads.

The interviews also revealed that the drivers often need to remove obstacles. Since an ADV cannot solve these kinds of problems like human drivers do the ADVs' Operational Design Domain (ODD) may need to be adapted to the ADV's capacity, e.g. being free of obstacles.

The letters and packages are delivered to the addressees by the drivers. With ADVs, these "hand-over" operations need to be either taken care of by someone at the addressees or be replaced by a delivery system that does not involve the hand-over to the addressees.

Another matter is that some general traffic rules are often vaguely formulated *("… adapt the speed to the bicycles…", "…adjust the speed so there is no danger…", "…to… in time…"*) and leave much to the drivers to interpret their meanings and to act accordingly. How ADVs should comply with this kind of traffic rules could be a challenge.

The drivers' gained experiences seemed to be key to handle unforeseen events and to solve problems as they occur, for example through compensating behaviour, such as position in lane, acceleration/deceleration, steering manoeuvres etc. A "dynamic learning function" could be an important feature to implement in a future ADV-system.

Overall, the interviews showed that the drivers are handling complex traffic situations and environments and that they need to manage many practical tasks to deliver the letters and packages to the addressees. Without human drivers a delivery system with ADVs would require a systems perspective throughout the whole logistics chain.

Key words: Electric delivery vehicles, Driver actions, Automated delivery vehicles, Traffic situations, Operational design domain

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Content

Preface

This report is from the GLAD project (GLAD: *Goods deliveries under the last mile with automated delivery vehicles*). GLAD was a research and development project with the overall aim to gain knowledge about user needs as well as about technical, societal, business and policy related challenges with automated delivery vehicles (ADV). The GLAD project was conducted during June 2020 and September 2022 and was coordinated by RISE Research Institutes of Sweden. The project was partly financed by the Swedish Transport Administration (ref. no. TRV 2020/26017). The partners in the GLAD project were RISE Research Institutes of Sweden, Aptiv AB, Combitech AB, Clean Motion AB and Halmstad university. The studies in the GLAD project are summarized in the following report:

- Söderman, M., (2022), *GLAD, Goods deliveries under the last mile with automated delivery vehicles - Summaries of the studies in the GLAD project*, ISBN 978-91-89757-24-0, RISE report 2022:135

The full reports from the studies in GLAD are:

- Andersson, K. (2022), *Autonoma leveransfordon – vad är de för sorts fordon och har det någon betydelse? (Eng. Automated delivery vehicles - what kind of vehicles are they and does it matter?),* ISBN 978-91-89711-44-0, RISE report 2022:100
- Söderman, M. (2022), *Typical and critical traffic situations with small electric delivery vehicles – indications for future automated delivery vehicles*, ISBN 978-91-89757-19-6, RISE report 2022:130
- Söderman, M., Andersson, J., Habibovic, A., (2022), *Use cases and high-level requirements for safe interactions between Automated Delivery Vehicles and human operators in a terminal,* ISBN 978-91-89757-20-2, RISE report 2022:131
- Andersson, J., Habibovic, A., *How to convey the intent of an automated vehicle with its longitudinal and lateral movements - evaluating four communication concepts in two traffic situations involving pedestrians* (Report under construction, 2022)
- Söderman, M., Clasen, R., Bergström, G., Collings, W., (2022) *Development of self-driving and control room functions and of external HMI for Automated Delivery Vehicles,* ISBN 978-91-89757-21-9, RISE report 2022:132
- Söderman, M., Clasen, R., Bergström, G., Collings, W., (2022) *People's understanding of external HMI and their experiences of interacting with an Automated Delivery Vehicle in a terminal context,* ISBN 978-91-89757-22-6, RISE report 2022:133
- Gonzales, S., Sveder, C., Oscarsson, E., Jönsson, S., (2022) *Challenges and potential business applications of Automated Delivery Vehicle initiatives - a brief overview,* ISBN 978-91-89757-23-3

Sammanfattning (Swedish)

I denna studie undersöktes vilka trafiksituationer som förare av små leveransfordon (eng. Manual delivery vehicles, MDV) råkar ut för och hur de hanterar dessa, ibland kritiska, trafiksituationer i sitt dagliga arbete. Syftet var att få en bild av vilka situationer som framtida självkörande leveransfordon (eng. Automated delivery vehicle, ADV) kan komma att råka ut (förutsatt att de kommer köra i liknande miljöer).

Nio förare på en av Postnords terminaler i Göteborg intervjuades om sina arbetsuppgifter, erfarenheter av typiska och kritiska situationer och hur de hanterar dessa situationer. Intervjuerna visade att många potentiellt kritiska situationer orsakades av fordonets låga hastighet (max 45 km/h) jämfört med andra fordon, t.ex. fordon kör mycket nära bakom dem och vårdslösa omkörningar sker på smala och trafikerade platser. Intervjuerna visade också att förarna ofta måste ta bort hinder för att komma fram. Eftersom en ADV inte kan lösa dessa typer av problem som förare gör idag kan det innebära att ADV:ns Operational Design Domain (ODD) behöver anpassas.

De brev och paket som körs ut levereras till adressaterna av förarna. Med ADV:er måste detta antingen tas om hand av någon person hos adressaterna eller ersättas av ett annat system som inte innebär att en person tar breven och paketen den allra sista biten till adressaterna.

Studien visade även att förarnas erfarenheter har stor betydelse för att köra säkert och effektivt och att de löser problem allteftersom de uppstår genom kompenserande körbeteende, t.ex. position i körfält, acceleration/retardation, styrmanövrar etc. En "dynamisk inlärningsfunktion" kan därför vara en viktig funktion att utveckla i ett framtida ADV-system.

Förarna nämnde även att vissa trafikregler är vagt formulerade *(”... anpassa hastigheten så att det inte uppstår fara...", "... anpassa hastigheten till cykeltrafiken...", "... att i god tid...")* vilket innebär att de måste tolka innebörden och agera därefter beroende på rådande trafiksituation. Hur framtida ADV:er ska förhålla sig till denna typ av generella trafikregler kan bli en utmaning.

Sammantaget visade intervjuerna att förarna hanterar komplexa trafiksituationer utifrån sina kunskaper och erfarenheter, samt att de, förutom att köra fordonet, måste hantera en mängd praktiska saker för att leverera brev och paket ända fram till adressaten. Utan förare måste ett leveranser med ADV:er genomlysas av en systemsyn på hela logistikkedjan.

1 Background

If automated delivery vehicles (ADV) are going to drive the last mile in the logistics chain on public roads and in public spaces, i.e. to transport goods from terminals to their final destinations, the ADVs need to have the capability to manage a range of everyday situations - expected and unexpected - from finding and getting to the final destination to manage obstacles that are blocking the road to drive among vulnerable road users (VRU), such as cyclists and pedestrians.

Today, there are manual goods delivery vehicles (MDV) transporting goods under the last mile in urban areas (Figure 1). This kind of transports could potentially be carried out by ADVs. However, the ADVs and the system managing the ADVs, must have the capacity to handle situations that the drivers of MDVs are facing and handling on an everyday basis to carry out their transport missions.

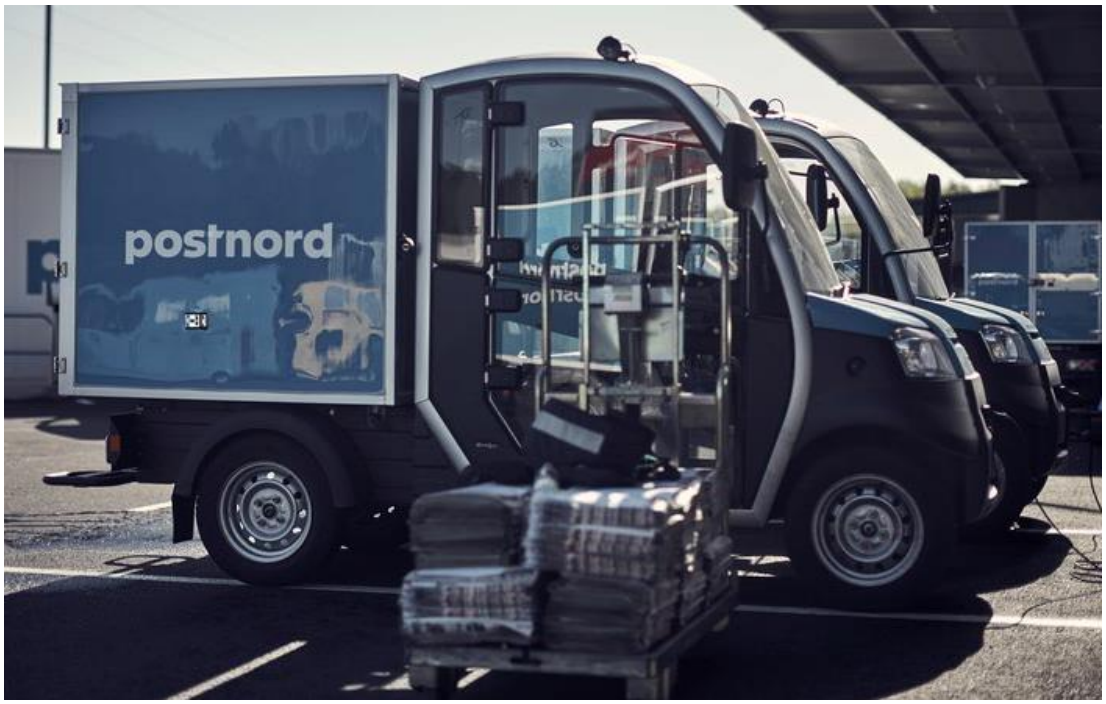

Figure 1. *The type of electric delivery vehicles that are used at Postnord for last mile deliveries, for example in Göteborg, Sweden (photo: Johan Stjerneus, Postnord mediabank)*

2 Aim and purpose

The aims of this study were to get an overview of (i) typical traffic situations that drivers of MDV are facing during their daily routes and (ii) how the drivers are handling these, sometimes critical, traffic situations. The purpose was to understand what situations future ADV may encounter. This knowledge can provide indications for future ADVs, but

also provide important insights about the operational design domain[1] (ODD) and the associated challenges that ADV systems need to have the capability to handle.

3 Method

The data was collected through semi-structured interviews with nine drivers of MDV (two women and seven men, ages 19-54 y, mean 30,7 y) at one of Postnord's terminals in Gothenburg, Sweden. The interviewees' driving experiences with MDVs varied from three months to more than five years. Due to Covid-restrictions the drivers were interviewed via phone. All the interviews were carried out by the same interviewer. The interviews took about 20 minutes and were carried out during the drivers' breaks. The interviews focused on the following topics:

- Working tasks
- Driving environment
- The drivers' general opinion and experience of driving the DV
- Critical situations: what, how often, where
- How the drivers' handled different critical situations
- Communication with other road users

4 Results

4.1 General

The main types of goods delivered with the MDVs are letters and small packages. Most driving is in urban and suburban environments and in daytime, but in wintertime the mornings and evenings are often dark. A typical working day includes two shifts (morning and evening) á three hours. During a workday the drivers drive from 5 to 20 kilometres depending on the route, number of deliveries, type of addressee (companies, residents etc.) traffic situation etc.

The drivers thought the MDV is generally good to drive; comfortable, weather protected, smooth, quick and easy to drive and handle. The small size makes the MDV manoeuvrable in narrow situations. The drivers often need to park and leave the MDV in order to hand over letters and packages to the addressees. When possible, they park the MDV in designated parking lots, but sometimes the drivers need to improvise and park the MDV elsewhere, e.g., when parking lots are occupied or if there is no parking lot available at all.

[1] The term Operational design domain (ODD) refers to the specific domain in which an automated driving system is designed to properly operate, including types of roadways, ranges of speed, weather, time of day, and environmental conditions.

4.2 Traffic situations

4.2.1 Other vehicles

The drivers stated that generally they do not encounter major problems or critical traffic situations while driving, but at the same time they mentioned several first-hand experienced situations that had been directly or potentially critical.

The MDVs' max speed is 45 km/h which is mostly fast enough to keep the same pace as other vehicles in urban environments. However, the drivers often experienced critical situations when the MDV cannot keep up the same speed as the other vehicles (which is common). The MDV's relative slow speed often causes irritation and risky manoeuvres by other drivers. Examples of traffic situations that arise due to the MDV's slower speed:

- Queues behind the MDV
- Vehicles driving (very) close behind the MDV
- Vehicles are turning close in front of the MDV
- Vehicles overtaking the MDV in various situations, such as:
    - Overtaking just before the road merges from two lanes to one lane
    - Overtaking just before curves
    - Overtaking in roundabouts
    - Overtaking close to the MDV
    - Overtaking on the wrong side (right hand side)
    - Overtaking in narrow environments
    - Overtaking when oncoming vehicles
    - Overtaking without giving notice (MDV driver not prepared)

The MDV drivers often adapt their driving behaviour to the situations to prevent potentially critical situations. For example, they drive in the middle of the lane to avoid other vehicles overtaking or squeezing past, which often happens if they drive in the right part of the lane. On the other hand, other vehicles sometimes try to overtake on the wrong side, i.e., the right-hand side. Another common situation is when a two-lane road merges to a one-lane road. Vehicles behind the MDV often accelerate and try to overtake just before the lanes are merging. Therefore, MDV drivers need to be prepared to brake/decelerate to let the overtaking vehicle drive past to avoid critical situations which also could involve the incoming traffic. Vehicles sometimes also overtake in two-laned roundabouts, which can cause critical situations.

MDV drivers need to be prepared to brake/decelerate when approaching crossings and roundabouts where other vehicles can suddenly drive very closely in front of the MDV, because they don't want to fall behind the MDV. The MDV drivers also have to manage situations due to violations of traffic rules by others, for example:

- Drivers not using the turning indicators
- Drivers driving with the rear lights off

- Drivers exceeding speed limits
- Drivers not giving way

4.2.2 Obstacles

The MDV drivers often encounter obstacles along their routes. Some obstacles the drivers can drive past, but sometimes the drivers have to remove the obstacle by hand, if possible. A common situation is e-scooters that have been parked, or thrown away, in places where they are difficult to see and, therefore, and can be hit.

Obstacles that cannot be removed may force the drivers to drive on the pavement to pass the obstacle, or sometimes need to find alternative routes in order to reach their destinations. In sum, the drivers often "improvise" to solve situations as they are encountered and in order to carry out their job, they sometimes need to violate traffic rules and park where parking is not allowed.

4.2.3 Vulnerable road users

Vulnerable road users (VRU), such as pedestrians and cyclists, can cause other types of situations the MDV drivers have to manage, for example, cyclists cycling on zebra crossings, and not yielding when they should, for example at crossings. Cyclists can also suddenly appear in front of them, for example at corners, exits, gates, hedges and at other places where the visibility is limited.

Many people are wearing headphones and cannot hear the MDVs and, therefore, step out in front of the MDV without noticing. Another common situation is people who are looking down at their smartphones while walking and crossing streets, which the MDV drivers must be aware of and be prepared to stop.

4.3 Communication with other road users

There are situations when the drivers communicate with other road users, for example to confirm that they have noticed each other and to clarify one's intentions and actions, by waving or nodding their head or using other gestures to communicate e.g. a "thank you" when people yield and let you pass. This kind of communication occurs mostly at crossings, pedestrian crossings, bus stops, exits etc. Some drivers mentioned that cyclists seem less inclined to communicate in traffic situations compared to other road users.

5 Discussion and conclusions

This study was carried out to get an overview of typical traffic situations that drivers of MDV are facing during their daily routes and how they are handling these situations. The objective was to get an understanding of the situations and challenges that ADV may encounter in the future, which need to be considered when designing an ADV-system. The study also provided insights about the ODD for ADV if should operate in public spaces in.

The interviews with the MDV drivers showed that the drivers did more than "just driving" the MDV to different destinations. In addition, they unload the MDV's compartment and deliver the letters and packages to the addressees. With ADVs these operations need to be either taken care of by someone at the addressees or replaced by a delivery system that does not include the hand-over to the addressees.

A major matter are the many potentially critical situations that the drivers experience due to the MDV's relative slow speed (max 45 km/h) compared to other vehicles, such as other vehicles overtaking in narrow and crowded situations, which in turn could lead to hazards. Having the capacity to drive with the same pace as other vehicles will, therefore, be critical for ADVs.

The drivers are regularly handling different situations caused by obstacles, and sometimes they have to remove the obstacles by hand. Since an ADV cannot solve this kind of problem like the drivers do the ODD for ADV must be free of such obstacles. There are also obstacles the drivers cannot remove (for example cars and trucks), and the drivers, therefore, need to find alternative routes. This kind of problem must also be managed by the ADV-system if such situations would occur in the ODD.

The drivers comply with traffic rules, but many traffic rules are often formulated vaguely ("… show consideration…", "…take into account…", "… adapt to…", "…have margin to…") and leave much to the drivers to consider their meanings and to act accordingly. How an ADV-system should comply with this kind of traffic rules could be a challenge from a legal point of view.

The drivers said that they rarely encounter critical situations, even though they could mention critical situations. An explanation could be that critical situations are not very common, but it could also be that the drivers have learned how to anticipate potentially critical situations and to act accordingly. It could also be that they have become used to these situations and, therefore, do not always think about them as critical. The drivers seemed to solve problems implicitly as they occur, for example through compensating behaviour, such as position in lane, acceleration/deceleration, steering manoeuvres etc.

The drivers' gained experiences seem to be key to drive safely and to handle critical situations. The more experienced drivers talked less about critical situations compared to the inexperienced drivers, which could be explained by the experienced drivers' ability to anticipate potentially critical situations.

In sum, the interviews showed that the drivers are handling complex traffic situations in their daily work, not to mention all the practical tasks they carry out to deliver the letters and packages. Without human drivers a delivery system with ADVs would require a systems perspective throughout the whole logistics chain.

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