

BARRIERS TO IMPLEMENTATION OF AUTOMATED COMMERCIAL VEHICLES IN GOODS DISTRIBUTION

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Abstract: *Development of automated vehicles (AV) has gained additional impetus due to a significant lack of professional drivers throughout Europe and America in recent years. Other latent problems are vehicle overloading, whose responsibility is the proper/inadequate cargo distribution and securing in the AV cargo compartment and its access control, how the freight loading/unloading/reloading will be carried out, as well as legal and financial liability in case of vehicle stability loss due to improperly distributed and secured cargo. There is a problem of allocating responsibility in case of AV malfunction or breakdown in operation, as well as who will generate requirements for vibration or noise related AV maintenance. Will it be necessary to change existing Incoterms rules or introduce new ones? Potential AV implementation barriers will be identified and reviewed in this paper, questions raised and suggested possible solutions to those issues, as well as defined potential supply chain actors' liability when involving automated vehicles.*

Keywords: *automated commercial vehicles, logistics chain, barriers, responsibility, road safety*

1. INTRODUCTION

Currently, automated vehicles (AVs) are increasingly gaining more significance every day and many companies are getting involved in their development in order to enhance road safety (accidents reduction), reduce congestion (total travel time reduction), as well as solve the problem of professional drivers' shortage in the commercial transportation sector. On the other side, their intention is to occupy the leadership position in this growingly innovative field. AV technology could make a major impact on lowering travel times, delays, accidents, congestions, energy consumption, as well as global environmental pollution caused by road transportation activities (Marchau et al., 2018). According to Fraedrich et al. (2018) the primary focus is the development of AV technology, as well as the effects on traffic flow, road safety, traffic congestion, exhaust gas emissions, parking problems and land use (adjustment in lane widths and layouts, removal of signage and need for drop-off and pick-up areas). Fagnant & Kockelman (2015) are among rare authors who consider AV application in freight transportation and

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benefits deriving from it. Besides companies dealing with AV development, these vehicles have drawn the attention of research community, planning practitioners and policy makers (Fraedrich et al., 2018).

Although it is not evident, many AVs are presently cruising on the roads worldwide, despite the fact that they are still not fully automated which is the ultimate intention. Today's AVs require drivers' presence and engagement since driverless vehicles are still not legally permitted in many countries, road infrastructure and their environment is not fully prepared for them and they are not operable in all weather conditions. AVs development rely on advanced driver assistance systems (ADAS), such as Forward Collision System, Adaptive cruise control, Automatic braking, Automatic parking and similar. Nevertheless, some ADAS have disclosed adverse impact on road safety since drivers relax and don't pay (sufficient) attention to traffic situations because they rely (too much) on these systems. In that way, they are exposed to additional unnecessary risk, which was not the case before the existence of these systems (Robertson et al., 2017). To better understand the levels of driving automation, Society of Automotive Engineers (SAE) defined the features of six levels of automation from no automation at all (level 0) to full automation (level 5) (SAE, 2018). These levels of automation and what they include are presented on figure below (Figure 1).

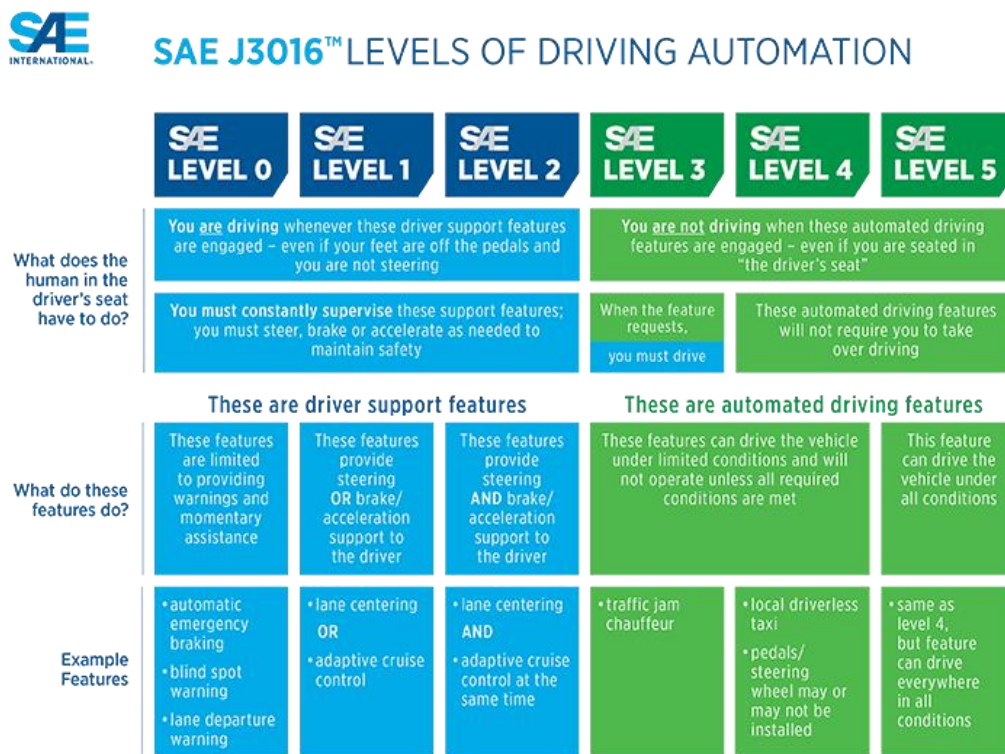


Figure 1. Levels of driving automation (SAE, 2018)

As it is shown on figure 1, levels from 0 to 3 require drivers' presence and some degree of engagement, so the driver (must) operate the vehicle in all times or certain moments. Namely, first three levels (levels 0, 1 and 2) require constant driver engagement in vehicle operation, while the fourth level (level 3) requires vehicle operation only when necessary and when vehicle requests it from the driver. Levels 4 and 5 are almost the same, with one key difference: level 5 vehicle can operate autonomously in all operating conditions, such as weather, visibility, and road conditions, so they have no impact on efficient vehicle

operation. Even if completely AV could independently operate without driver's presence and is able to overcome all the obstacles, some barriers still arise and represent setbacks to their efficient implementation in existing commercial transportation.

The paper is structured as follows. Chapter 2 contains previous research about AV application and identified issues in this field. Chapter 3 refers to the obstacles occurring an efficient AVs implementation in the transportation system, especially in view of commercial transportation, while the conclusions and future research are given in Chapter 4.

2. PREVIOUS RESEARCH

Authors were until now dealt with different AV implementation problems. In that sense, some authors consider the link between parking policy and automated vehicles (AV parking problem) (Millard-Ball, 2019), some of them consider adaptation of AV users behavior on non-fully automated vehicles (Robertson et al., 2017), then effects on urban planning and built environment (Fraedrich et al., 2018), high price of AV vehicles and how to overcome this barrier (Masoud & Jayakrishnan, 2017), Crayton & Meier (2017) consider the influence of AV on public health, while Sraub & Schaefer (2018) in their paper deal with users interaction on transport network, including AV, other drivers, pedestrians, bicyclist. Besides above mentioned, Sraub & Schaefer (2018) define policy issues regarding responsibility of control allocation, communication of AV with pedestrians and bicyclist, the courtesy problem and communication with other drivers and the second vehicle problem.

Fraedrich et al. (2018) imply that AVs not only have influence on vehicle flow and usage, but that they have a lot bigger importance, thus the authorities should make plans and strategies to implement and approve this new technology. Regarding this Crayton & Meier (2017) emphasize that for each level of automation new policy implications occur and there is a constant need to adjust transport policy to AV. Different policy makers are extremely interested in wider usage of these vehicles, but development of transport policy in this field is tied to many uncertainties regarding evolution and application of AV (Marchau et al., 2018). According to Sraub & Schaefer (2018), it is almost impossible to establish or make transport policy regarding AV since these vehicles are liable to significant changes which could have impact on creating the transport policy. In that sense the authors of this paper quote that it is necessary to pay attention to other obstacles which will definitely exist after AV implementation (when the obstacles in development of AV technology are overcome), especially in case of fully automated vehicles. In accordance with Sraub & Schaefer (2018) also in this paper the aim of the authors is to give proposals, not only to policy makers, but also to manufacturers (researchers) of AVs, that should be taken in consideration in order to define necessary standards, policies and AV construction, so that AV could be easily implemented in existing transport system. In addition to that some procedures need to be defined and the focus should be particular parts of transport policy which are not closely connected to AV technology and their impact on the other traffic participants (other vehicles, bicyclist and pedestrians), environment, traffic congestion, etc.

Through extensive literature review which refers to AV, it is notable that most papers are focused on individual passenger cars, but only small number of papers are dealing with commercial AVs. The authors consider that further attention must be paid to the

commercial transportation sector since it is one of the sectors which AV implementation will have a major impact on. This is due to a significant professional drivers' shortage throughout Europe and America in recent years, as well as because the opportunity for transport companies to achieve additional profit by not engaging drivers (no labor cost), widening distribution time-window, eventually enabling 24/7 deliveries. Also, vehicle operation will not be limited as currently by drivers' availability in the sense of working hours, driving time, rests and similar.

Of course, for this transition toward fully automated fleets to run smoothly and efficiently, without major problems and obstacles, it is necessary to develop a technical logistics system in transportation and logistics companies. In that sense, different barriers have been identified and considered in the next chapter in order to be prepared for the eventual implementation of AVs in the supply chain.

3. BARRIERS IN THE GOODS TRANSPORTATION SECTOR

Hereafter the authors present an overview of barriers and risks that may arise in goods transportation by AVs. Some of the outlined barriers require precise allocation of duties, responsibilities, costs and losses of different participants in logistics chain.

Barrier 1: vehicle cargo problem

One of many problems which should be solved is vehicle overloading aimed at increasing operator's competitiveness and profit at the expense of road safety. Besides technology development, which is currently the most significant obstacle, compliance with EU legislation in force regarding motor vehicles appears as a barrier to smooth AV implementation. Directive (EU) 719/2015 defines that by May 27, 2021 critical vehicle (and vehicle combinations) categories regarding potential infringements of maximum authorized weight and/or axle load limits must be identified, in order to facilitate their enforcement and ensure their better compliance with these rules. In that sense, there are two possible options: automatic systems embedded into the road infrastructure (for dynamic vehicle weighing) or on-board weighing equipment (sensors) installed in commercial vehicles. For economy reasons, since the implementation of smart tachographs, equipped with Dedicated Short-Range Communication systems facilitating remote enforcement, is envisaged for mid-2019, it is also expected that new commercial vehicles will be equipped with such on-board weighing equipment (sensors), integrated with tachographs. Aforementioned equipment (sensors) must be accurate and reliable, fully interoperable and compatible with all commercial vehicle types.

One of possible solutions to this problem would be fitting AVs with sensors that will measure and display axle load though providing a direct insight into this. In that sense the personnel responsible for loading could have valuable information on the current state of axle load and the remaining maximum quantity of goods to be added to each individual axle and therefore to dispose of an on-board cargo distribution tool. If the maximum permissible axle load is exceeded this system could inform the user via a visual or acoustic warning signal on each individual axle, and how the cargo should be rearranged (where to). AVs should be fitted with a provision for identifying, monitoring and protection against tampering, manipulations and fraud. Of course, a serious concern should be given to prevent possible manipulations through hacking the AVs and programming it not to register excessive axle loads, or setting the axle load on a higher weight value than

designed or prescribed. In terms of remote (short-range) enforcement of AVs in order to prevent software manipulations and tampering attempts.

If a manipulation is unambiguously determined and identified, e.g. if AV on-board system is hacked, the question is who will be held responsible for this manipulation and who will cover the incurred fines and expenses? According to authors' opinion, this obligation of AV monitoring and therefore responsibility should lie on the company the AV owner/user (vehicle/fleet responsible person). Mainly because this responsible person should take care of the whole vehicle fleet, both if the AV are parked in the company premises or they are presently engaged in goods transportation.

Considering that at the highest level of automation the presence of a driver will not be necessary (and therefore not foreseen), the issue will be: who will take responsibility for the proper/inadequate cargo distribution and securing in the AV cargo compartment, especially when the maximum authorized axle load will be exceeded identified in roadside checks. Also, the problem of cargo compartment access control (its entirety or some part of it) arises, as well as how the freight loading/unloading/reloading will be carried out, especially in cases where one vehicle supplies multiple users (city distribution). Another problem of legal and financial liability in case of vehicle stability loss due to improperly distributed and/or secured cargo particularly when it causes a road traffic accident, cargo / vehicle damage, or human fatalities.

Those problems can be overcome by constructing the AVs in such a way to limit access to cargo compartment(s)/units only to authorized persons, especially in case of a city distribution or a delivery to multiple users. In that sense, if there were irregularities in cargo loading / unloading / reloading, the responsible person should be the last one that had the access to the precise cargo compartment(s).

The question of cargo safety during transportation should be also considered – what happens and who is the responsible if the cargo is damaged during transportation. Whether liability is on the last person who has access to cargo compartment and how to prove that the cargo wasn't secured properly. Therefore, the AV and/or cargo compartment should be equipped with additional equipment, monitoring systems or sensors in the cargo area. With appropriate facilities it could be proven why, how and in what moment the cargo was damaged. It is essential to determine what caused the damage: was it inadequately arranged or secured cargo or some segment of AV operation caused it, such as inadequate acceleration, insufficient braking, deficient maneuvers, etc.

In terms of cargo security, thefts should be considered and prevented, as far as possible. Since this is a common problem even when the drivers are in or around the vehicle – thefts happen. AVs are programmed to upgrade road safety and therefore will stop if the road is blocked, someone put barricades, or another vehicle stopped in front of it. All obstacles will prevent AV's passage and make it vulnerable to "road pirates". In cases when AV registers unauthorized or illegal access to its cargo compartment(s), it should notify the police and the company owner/user immediately and record the whole event with camera(s) or similar monitoring provisions. Nevertheless, for cases of theft, the company should have cargo insurance and cover the expenses to cargo owners and transport service users.

Barrier 2: vehicle maintenance and breakdowns

There is a problem of allocating responsibility in case of AV faults, failures, malfunctions or breakdowns in operation, for vehicle towing, traffic congestion and eventual related road accidents? Meanwhile, in the framework of AV maintenance and repair, the following question arises: (in lack of driver/operator) who will generate requirements for vibration or noise related AV maintenance, aside from irregular or legally inadmissible vehicle operation, such as inefficient acceleration, insufficient braking, etc.

As it's defined and planned so far, it is anticipated that AVs will be failsafe and technologically advanced enough to perform complete start-up and continuous self-diagnostics to determine (present or imminent) faults, failures, malfunctions or breakdowns, as well as if it realizes so, to determine could they affect operation or road safety (of other road users). According to this paper authors assuming that AV will be far better fitted with ADAS than current vehicles, it is necessary for AVs to have such real-time diagnostics system to monitor and predict imminent failure(s) of AV systems, components or elements, so that at the adequate moment leaving safely the traffic flow without compromising other road users. In addition to systems that would constantly monitor the condition(s) of AV and all of its components, there is also the possibility to install additional back-up systems designed to serve as emergency replacement if main system fails. This would of course drastically increase the cost of AV, but when it comes to human lives and injuries, this increased price definitely should not be a limitation criterion. AV should pass to a back-up system (if available), override the faulty function, restart software, allow remote diagnostics and/or troubleshooting, reach road assistance or contact stationary maintenance service center and/or repair workshop. This is very important when considering the beginning of AV implementation, since a sudden breakdown on the road can affect drivers of other (non-automated) vehicles and eventual accidents could occur caused by untimely or inadequate reaction of involved road users. Just imagine the consequences of high-speed driving behind and close to an AV on the highway and it experiences a sudden fault, breakdown or stop due to a failure.

Moreover, authors consider that if AV detects some system tendency to fail (in the near future) or if a system has failed and is replaced by a back-up system, but needs to be repaired or maintained, AV should be designed in such a way as to send a request to the nearest service center to which it can arrive driving safely, otherwise it shall automatically call the towing service that would take it to the first service center or wait for a mobile expert trained repairman to repair it.

Based on all mentioned and the aspiration of manufacturers for AV to be always in (near-)perfect condition and that their operation will not be possible if some major system is down, the question of the need of AV periodical technical inspection arises. In our opinion, if AVs are able to control its components in some of all of aforementioned ways, a periodical technical inspection as a prevention will not be needed. On the other hand, this would require monitoring of all AV components, which means the installation of additional control systems that further increase the AV price, total mass, fuel consumption (due to increased mass), as well as fuel costs and environmental pollution. So, another proposal is to constantly monitor the AV key (critical) components which failure could lead to a road accident, and not critical components degrading slowly or with long lifecycle period should be tested on periodical technical inspection.

Barrier 3: Smart tachographs YES or NO?

The next question arising is whether the existence of a tachograph in AVs is really necessary, especially in the case of Level 5 automation. If it would be defined that the presence of the driver is not necessary in the AV, the main purpose of tachographs would be obsolete, since there would be no need to monitor the (inexistent) driver's working, driving, break and rest periods. On the other hand, if it would be defined that the driver must be in the AV, does it mean that it is necessary to change the legal basis since the driver would not be exposed to so much effort because he is not operating the vehicle constantly (Level 3 and 4), or at all (Level 5) and thus he doesn't have to take obligatory breaks after 4.5 h of continuous driving period. Is it necessary to define additional (framework) legal provisions such as the AETR agreement, which are only applicable when the driver is in the AV. Would this make additional complications in terms of monitoring and enforcing drivers (which is already quite complicated) since the driver can be engaged in operating non-automated vehicle during certain days, and operate AVs during others. It is also important to consider whether the transportation and logistics companies want to pay drivers "just to sit in the AV and do nothing". If they don't, the additional wages reduction due to reduction of work duties would represent a major issue demanding to be solved, since the drivers are already underpaid. So, it may be necessary to engage trained personnel (e.g. engineer) with specific expertise to remain in the vehicle, to monitor cargo distribution and securing, to intervene in cases of AV faults, failures, malfunctions and breakdowns. Also, the tachograph can assume a "black box" function in AVs, such as in airplanes. In this case, the tachograph, should record all the AV parameters in real-time and in case of traffic accident it can provide all relevant information regarding AV operation before the accident happened. This could help establish if the AV caused the accident or something else, anyhow the initial purpose of the tachograph as we know it would be changed.

4. CONCLUSION

The primary goal of this paper is to draw attention to possible barriers which would inevitably occur when AVs are implemented in the commercial transportation, specifically in freight transportation. The authors of this paper focused on the possible barriers that may arise during implementation of commercial AVs, and emphasize the need for further research in this field. The paper examines barriers such as axle load (especially overload), responsibility for the proper/inadequate cargo distribution and securing, cargo compartment security/access control, vehicle stability loss due to improperly distributed and/or secured cargo. Besides that, the AV maintenance problem and faults, failures, malfunctions and breakdowns were examined and what should be done in that situation, as well as the necessity to use the tachograph in observed vehicles and what should be done with existing international and national legal framework. Some of the responsibilities of the participants in the logistics chain regarding mentioned barriers were proposed. One of the future research directions is detailed consideration of the Incoterms rules and defining all obligations, responsibilities and expenses of participants' in the logistics chain where commercial AVs are engaged.

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