Issued: January 2022

Future Truck Committee Position Paper: 2022-1

Recommendations Regarding the Need to Study Potential Driver Disengagement Related to Advanced Driver Assistance Systems and Piloted Automated Driving Systems in Commercial Trucking Operations

Developed by the Technology & Maintenance Council's (TMC)
Future Cab & Driver Interface Task Force

ABSTRACT
ATA's Technology & Maintenance Council — through its Future Cab & Driver Interface Task Force — reviewed research conducted by the Virginia Tech Transportation Institute (VTTI) and the Massachusetts Institute of Technology (MIT) AgeLab, which have studied the performance of passenger cars equipped with multiple Advanced Driver Assistance Systems (ADAS) operating at SAE Level 2 automation, and SAE Level 3 piloted Automated Driving System (ADS). This research identified behavior defined as "driver disengagement" due to an over-reliance on technologies to maintain safe operation of the vehicle, which is documented to be a factor in causation sequences leading to crashes. TMC recommends that industry research if, and to what extent, "driver disengagement" may be occurring in medium- and heavy-duty trucking operations, and how technology and cab design can mitigate associated safety risks.

INTRODUCTION

ATA's Technology & Maintenance Council — through its Future Cab & Driver Interface Task Force — reviewed research conducted by the Virginia Tech Transportation Institute (VTTI) and the Massachusetts Institute of Technology (MIT) AgeLab, which have studied the performance of passenger cars equipped with multiple Advanced Driver Assistance Systems (ADAS) operating at SAE Level 2 automation, and SAE Level 3 piloted Automated Driving System (ADS). (See **Figure 1**). Research indicates when these systems are in operation — and to some extent even when the technologies are not active — deterioration occurs in driver attentiveness, situational awareness, and the ability to take needed interventive actions. This behavior is defined as "driver disengagement" due to an over-reliance on technologies to maintain safe operation of the vehicle.

Technology & Maintenance Council (TMC)
950 N. Glebe Road • Arlington, VA 22203 • Ph: (703) 838-1763 • FAX: (703) 838-1701
tmc@trucking.org • http://tmcconnect.trucking.org/tmc

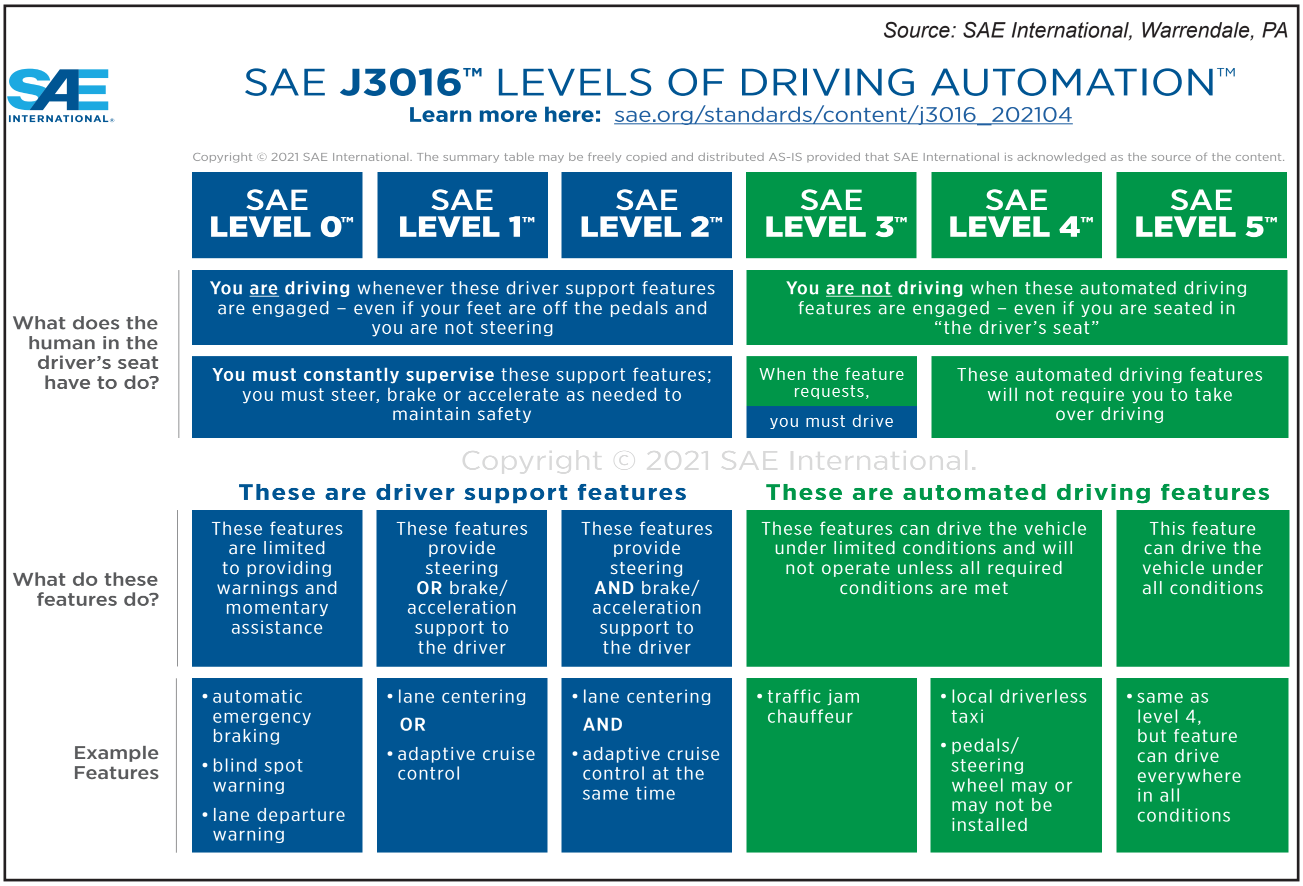

Figure 1

This behavior can be measured as a decrease in the driver's "attention buffer value," which is defined as the driver's ability to acquire and process highway situational information related to Safety Critical Events (SCEs), and has been documented in the causative sequences immediately preceding crashes.

ADOPTION OF ADAS TECHNOLOGIES

ADAS technologies are being rapidly becoming new vehicle standard specifications on medium- and heavy-duty (Class 4-8) commercial vehicles. At the same time, piloted ADS commercial vehicles are both in demonstration and initial operational deployments; in one case, fully autonomous operation is being demonstrated.

The Tech-Celerate Now Program, led by the Federal Motor Carrier Safety Administration (FMCSA) with cooperation by ATA/TMC and various industry groups, is actively promoting the adoption of ADAS technologies. Tech-Celerate Now's mission is to educate and promote the safety benefits of ADAS for trucking fleets and measure the impact of the program's outreach campaign in terms of ADAS adoption rates and truck crash reduction.

One of the four ADAS technology categories (Braking, Steering, Warning and Monitoring) being actively promoted is Monitoring, which includes in-cab facing driver monitoring systems (DMS) for training, forward-facing event recording and 360° direct vision. These systems use in-vehicle DMS devices and other sensors to monitor driver behavior and performance, enhance 360° field-of-view, and help employers provide driver feedback and improve driver performance. Therefore, it is important to understand if similar driver behavioral impacts are occurring, or potentially may occur in the medium- and heavy-duty vehicle environment; and determine factors which may mitigate unintended adverse safety impacts. Details from research conducted through the Tech-Celerate Now program indicate that current ADAS implementation on Class 8 trucks exceeds those of other vehicle classes. While availability of the technology is accelerating, the acceptance of technology usage is another story.

For example, 100 percent of Class 8 trucks built between 2019 and 2021 have the option to specify automatic emergency braking (AEB) and adaptive cruise control (ACC). With the addition of Lane Keeping Assist (LKA), commercial vehicles can have the capability to operate at SAE Level 2 automation.

However, many fleets choose not to include ADAS on their vehicles and Tech-Celerate Now has identified these barriers to adoption. According to Tech-Celerate Now Program Co-Principal Investigator Dan Murray, American Transportation Research Institute (ATRI), the most influential factor in deciding not to purchase ADAS, from both driver and carrier respondents, was concern over driver control being compromised.

As more vehicles come into the market with Level 2 capabilities,concerns have arisen in industry as to how these ADAS technologies work together and with other systems in the cab. For example:

1. How will SAE Level 2 technologies work together?
2. How will these technologies impact the driver:
    a. Will these automated safety technologies create "over-trust" issues?
    b. Can they cause distraction from the driving task?
    c. How do these technologies affect driver's sense of control?
3. Can a driver safely re-engage in the driver task?
4. How will monitoring tools such as driver facing cameras be used to mitigate these effects?

When Level 3 ADS comes into play — where the driver will be required to take control of the vehicle in an emergency or when there is a system malfunction — will the driver be able to fully reengage in the active driving tasks quickly enough?

In developing the background material for this Position Paper, TMC has explored the existing technical approaches and potential solutions for trucking to mitigate potential impacts of over-trust and disengagement, and as a result has developed a recommendation that additional trucking-focused research should be pursued. One of the objectives would be to develop methods to evaluate the effects of cab design on driver attention and how real-time monitoring may be effectively employed to mitigate risks associated with driver disengagement.

CURRENT DMS APPROACHES

DMS is used to track driver drowsiness and distraction, and perform safe vehicle-initiated hand over in semi-autonomous vehicles [1]. DMS utilizes driver facing cameras that monitor the driver's eye movement, eye lid movement, and head postures. It uses this data to determine if a driver is alert and awake. If a driver is not paying attention to the road ahead, the vehicle may provide a warning, and if the alert is ignored, may apply the brakes or otherwise intervene. DMS is intended to reduce crashes related to drowsy or distracted driving. These systems could potentially be used to check that a driver is capable of taking back control of the vehicle after executing a transfer of control from fully automated driving modes.

Many current DMS monitor driver distraction, but do not directly consider engaged driver attention. The difference is that driver distractions pull driver attention from the road, for example, to look at the display, maps, phones, radios, system alerts, etc., whereas driver attention can wander away from the road due to over-trust and boredom in driving.

A June 2020 *FleetOwner* white paper [2], describes the problem as one where "the most dangerous distractions are visually demanding tasks that take drivers' eyes off of the road." Although there are many things that can distract a driver's attention, this is not the same issue as measuring driver engagement in terms of attention over multiple series of on-road glance to off-road glance transitions and back to on-road. This white paper, does not address how to measure and manage driver attention to maintain on-road attention that supports constructive situation awareness and a safe level of driving.

The problems associated with driver attention presumably will increase as more automated technology is added in the move into Level 2 and eventually Level automation, which will require drivers to be ready to take over control on short notice.

CURRENT RESEARCH ON DRIVER DISENGAGEMENT

Although there is strong evidence that single-point solutions like AEB are having a significant reduction in crash rates, the results become more complicated when multiple safety systems operate simultaneously. AEB systems, an SAE Level 0 system, provide momentary assistance. To rise to Level 2, AEB requires LKA and ACC to be working at the same time. It is in Level 2 and Level 3 that the effects of the systems become more complicated and may create over-trust issues for the driver. These over-trust issues create challenges for the driver to maintain appropriate attention on the road ahead.

Recent research on Level 2 systems in passenger cars indicates that the driver can become disengaged from the driving task. In a 2019 study at VTTI [3], researchers looked at how driver behaviors changed as Level 2 systems such as LKA and ACC are added in passenger vehicles. Drivers with Level 2 systems active had 1.8 times the odds of engaging in a secondary task than when Level 2 was available but not active. When drivers were involved in a secondary task with Level 2 active, they spent almost 30 percent of the time with their eyes off the forward roadway. In addition, drivers with Level 2 active took more frequent and longer duration non-driving-related task glances, subsequently spending less time with their eyes on driving-related tasks. Also, the study found that when Level 2 systems were active, drivers were more than 50 percent likely to experience drowsiness than when the Level 2 system was non-active. This study suggests that as Level 2 systems becomes active, driver engagement decreases and drowsiness increases.

Research at the MIT AgeLab [4], showed significant shifts in driver glance patterns when using Level 2 automation systems versus manual driving. This study also indicates that when using Level 2 systems, drivers are more likely to drive "hands free" or have their hands in a low control position on the steering wheel.

Another study led by the MIT AgeLab assesses how drivers leverage automation and characterizes behavioral patterns associated with complete automation disengagement. This study describes the use of Level 2 systems and transfers of control as an integral part of a continuous, dynamic interaction between driver and automation, providing an understanding of when and why drivers assume control. The study found that when available, drivers tend to use Level 2 systems frequently, and often initiate transitions between automation levels, temporarily taking over the longitudinal and/or lateral control of the vehicle. These transitions are not necessarily related to immediate risk mitigation [5]. These research projects also suggest that as Level 2 systems become active, driver engagement decreases and drowsiness increases.

There is speculation that these issues affect a driver's sense of control in the driving task. Current approaches to DMS in trucking are tracking distraction, but not driver engagement and leave a gap in their ability to support drivers maintain a safe level of engagement.

REGULATORY ENVIRONMENT

In February 2020, the U.S. National Transportation Safety Board (NTSB) recommended the use of DMS as an effective means of driver engagement in Level 2 vehicles. In Europe, the Euro New Car Assessment Program (NCAP), which was based on the US NCAP five-star rating program for new passenger vehicles, has evolved to include DMS requirements and expanded to cover trucks. Euro NCAP recognized the importance of DMS in its revised crash-test safety standards, which now requires DMS for a five-star rating on all new vehicles, including all weight classes of trucks (N1, N2, N3) and all classes of passenger buses (M1, M2, M3).

Table 1 summarizes the emerging regulatory environment for DMS. Euro NCAP establishes testing requirements on DMS for drowsiness and distraction. In addition, the United Nations Economic Commission for Europe (UNECE) Autonomous Vehicle regulations for Steering (ECE R79) and LKA (ECE R157 S6) both require gaze detection for determining driver attentiveness on model year 2022 vehicles. In 2020, the ECE also proposed a requirement for continuous monitoring of driver drowsiness [6].

In the US, the regulatory approach has been more of guidance than regulation. The National Highway Traffic Administration (NHTSA) AV 2.0 guidance document encourages the use of DMS. However, legislation has been previously introduced in Congress calling for new research and regulatory action related to DMS in passenger cars. Given expanding globalization of new technologies in the automotive industry, the impact of regional regulations on DMS are likely to have an impact on both US regulations, as well as upon product development decisions by original equipment manufacturers (OEMs) and suppliers.

CONCLUSIONS

TMC recommends that industry undertake research on medium- and heavy-duty (Class 4-8) vehicle operations utilizing multiple ADAS technologies (Level 1 and Level 2) and piloted ADS at Level 3 to determine if unintended adverse safety related effects may occur due to changes in driver behavior related to these operations. The specific objectives of this research should be to determine:

- If, and to what extent, the behavior identified as "driver disengagement" documented in research related to ADAS and ADS technologies in the operation of passenger vehicles is or has the potential to occur in Class 4-8 operations.

TABLE 1: DMS — GLOBAL REGULATORY MATRIX

	DDAW Drowsiness Warning	ADDW Distraction Warning	Driver Sudden Illness	Hands off Eyes on	Driver Availability ADS L3
UNECE				ECE R79	ECE R157
EU 2019/2144	2022/2024 Camera				2022
Euro NACP	2022/2024	2022/2024	2023?		
Kr/China NACP	Like EU?	Like EU?			
US NACP					
Japan			Issued		

- The impacts that the increase in additional technology-related tasks (both driving and non-driving) which are uniquely related to medium- and heavy-duty commercial vehicle operations may affect these behaviors.
- The role that current DMS plays in mitigating such "driver disengagement."
- Whether, and to what extent, differences in cab design relative to ADAS, ADS and other technologies affect these behaviors.
- The potential impact of a trucking-specific methodology, utilizing both on-board and off-board technologies and systems, for assessing and mitigating, building upon results of previous research in passenger cars.
- Provide a basis for development of recommended practices for optimizing driving behaviors in medium- and heavy-duty commercial vehicle operations through human-machine interactions with ADAS and other on-board technologies to achieve safe, efficient and cost effective results for fleets.
- Provide technology-based rationale for use in potential regulatory advocacy.

Given the potential for regulatory development regarding driver monitoring, TMC further recommends that such research be pursued as a cooperative government/industry/academia project, preferably through an organization that will facilitate active industry input and oversight, such as ATRI. To this end, TMC has submitted a research topic proposal to ATRI's Research Advisory Board for consideration in ATRI's research agenda.

REFERENCES

[1] Coughlin, J. et el. *Monitoring, Managing and Motivating Driver Safety and Well-Being*. IEEE Pervasive Computing, 10(3). 2011

[2] Gonzalez, L. et el. *Proactively Spotting Distracted Driving with Advanced Technology. FleetOwner* White Paper. June 2020.

[3] Dunn, N. et el. *Understanding the Impact of Technology: Do Advanced Driver Assistance and Semi- Automated Vehicle Systems Lead to Improper Driving Behavior?* Virginia Tech Transportation Institute. December 2019.

[4] Morando, A et el. *Driver-initiated Tesla Autopilot disengagements in naturalistic driving. Proceedings of 12th International Conference on Automotive User Interfaces and Interactive Vehicular Application*s (AutomotiveUI '20). *https://doi.org/10.1145/3409120.3410644* September 2020.

[5] P. Gershon, et el. *Transitions in Automation: Evidence from Naturalistic Study in The 7th International Conference on Traffic & Transport Psychology*. Gothenburg, Sweden. 2021

[6] *Proposal for Supplement 1 to the original version of UN Regulation No. 157 for Automated Lane Keeping System*. TRANS/WP.29/2021/17. December 2020.