AUTOMATED VEHICLES

The Hand-Over Concept

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Automated vehicles that can assume the complete driving task under limited conditions correspond to Level 3 automation as defined by the National Highway Traffic Safety Administration (NHTSA).[1] This fact sheet explores the limits and capabilities of Level 3 automated vehicles, as they offer a promising means to help improve road safety for all drivers. For older drivers in particular, these vehicles can enable them to continue to drive safely as they age. With this technology, drivers may be able to have the vehicle control critical driving functions, including monitoring the road, steering, and accelerating and braking, under limited conditions. Depending on the capabilities of the automated technology, presence of inclement weather and prevailing road and traffic conditions, the system may hand-over control to the human driver when the technology cannot safely manage the road conditions.[2]

For the full benefits of Level 3 automated vehicles to be realized, it is important all drivers using this technology receive proper education and training, as well as understand the strengths and limitations of these vehicles. Otherwise, there may be no measurable benefits to road safety. Recent findings suggest feelings of knowledge and safety are positively related to the likelihood of using these vehicles. In particular, aging drivers are interested in learning more about these vehicles, and are receptive to strategies and tools to help them learn how to use these vehicles in ways that maximize their safety benefits.[3] As such, the benefit of these vehicles for drivers will depend on their knowledge and understanding of the functionality of these vehicles, specifically, the limitations of the technology and how vehicle control will be handed over to drivers when prompted, or how drivers choose to retake control.

To address this need, an overview of the hand-over concept is provided and key points about potential limitations of the process are summarized.

Questions & Answers

What is the hand-over concept?

Vehicles with conditional automation (Level 3) will require drivers to take control when the Automated Driving System (ADS) cannot navigate the road, due to unexpected hazards, unsafe road conditions, or unmapped roadways. To date, human drivers remain

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more capable of navigating such instances. The *hand-over concept* refers to the way vehicles transfer control to drivers when the technology's capabilities are exceeded or the system fails.

In what situations might the vehicle hand-over or transfer control to the human driver?

Bad weather, hazardous driving conditions, unexpected or unrecognized obstacles, and unmapped roads are all situations where the hand-over process can occur. Drivers should be aware they still need to remain engaged and prepared to take over driving tasks when requested to do so by the system. The hand-over of control may also occur if the automated technology were to malfunction.[4] Therefore, drivers need to maintain core driving competencies and remain attentive even when the technology is engaged.

How long will I have to regain control of the vehicle once prompted?

Once prompted, drivers must respond immediately to regain control of the vehicle and safely navigate the driving environment. Most often, it will be just seconds between hazard detection and driver notification to resume control.[5] For this reason, drivers must remain alert while using these vehicles. The time and distance between the vehicle and potential hazard plays a key role in the execution of a safe response.

For example, vehicles equipped with adaptive cruise control and lane keeping assist can maintain lane position while responding to traffic speed. However, unexpected obstacles, such as a change in road conditions, weather or encountering unexpected or unidentifiable obstacles (some obstacles you want the car to drive through like a floating plastic bag), oncoming collisions or wildlife, exceed the response functions of the system. In these scenarios, control would be returned to drivers.

Drivers may not be confident in their ability to resume control, especially older drivers, as age-related issues may cause reaction time to be slower.[6] Therefore it is essential for all drivers to receive proper training and education, especially those who may have trouble with the hand-over feature of automated vehicles, specifically in recognizing and reacting to a controlled hand-over.

How will I be notified the vehicle is handing over control?

The hand-over may be accompanied by visual and/or auditory cues, potentially haptic as well, but this will depend on the system.[7] Depending on the technology, it may include a combination of these signals unique to the brand and/or model of vehicle. The onus will be on drivers to understand the limitations of the technology and be prepared to take over control in situations where the ADS cannot function safely.

Will the technology return control of the vehicle in situations where no immediate hazard is present but the road environment is too complex?

Yes.[8] If road construction has occurred that has not been uploaded to the mapping system used for navigation, or unexpected road obstacles such as construction are present, the system will hand-over control. Further, as vehicles attempt to navigate the road, it is likely the hand-over of control may be prompted in response to complex urban and suburban environments with vulnerable road users such as pedestrians or cyclists. When attempting to navigate these roadways it is likely control will be handed over if the system becomes overwhelmed by urban roadway activity.

Is it possible these vehicles may not register the need to hand-over control and drivers will have to manually take over control of the vehicle?

Yes. Although the sensors should detect most hazards requiring human navigation, there is always

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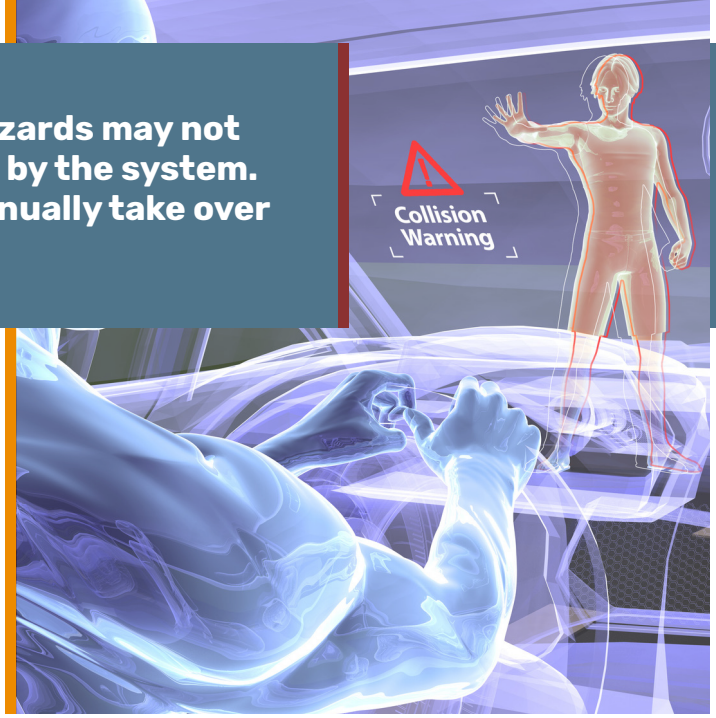
There is always the possibility some hazards may not be properly registered and interpreted by the system. In this scenario, drivers will have to manually take over control of the vehicle.



the possibility some hazards may not be properly registered and interpreted. For example, it has been reported that unmapped stop lights and signs may not be detected by these vehicles or may be damaged, or obscured.[9] In these cases, drivers would have to manually take over control and re-engage in the driving task to safely navigate the situation.

Could the vehicle hand-over control even after it has managed to safely avoid a hazard?

Yes. These vehicles are not perfect in their ability to interpret and respond to changing road environments. The vehicle may hand-over control in the event of a secondary hazard that developed as a result of how the vehicle responded to the initial hazard. In those situations, drivers must respond to the secondary hazard and may have to manually take control of the vehicle if it fails to register that control should be transferred.[10] For example, if the vehicle's system made a lane change to successfully avoid an animal who suddenly ran out into the road, the human driver could be required to take over control if the vehicle ahead also stopped abruptly in response to the same hazard. This demonstrates the need for drivers to be continuously aware and anticipate hazards as if they were driving the vehicle themselves.

Can I receive more advanced notice before control is handed over (e.g., a minute or two-minute warning)?

Due to the complex and constantly changing road environment, and the short time it takes to cover a considerable distance at highway speeds, this possibility is unlikely. This is why fully engaged and capable drivers are required for the benefits of this technology to have a positive impact on road safety. This also demonstrates the importance of drivers being properly educated about vehicle functions of the vehicle they are driving and the situations in which they would have to resume control of their vehicle.

Conclusion

This fact sheet describes the limitations of the hand-over concept. It highlights the important role drivers continue to play during adoption of these vehicles. It is clear Level 3 automated vehicle technology holds promising advancements in road safety. However, to safely use these vehicles, drivers must remain attentive and engaged in the driving task. For this reason, this technology requires drivers to avoid distractions and impairments that would delay reaction times and instead remain alert throughout the trip.

Moreover, this technology requires drivers to maintain core driving competencies, as they will need to navigate the driving environment when automated technology cannot function. Currently, no technology exists that eliminates the role of drivers from the driving task. Theoretically, only vehicles with full automation (Level 5) would require no human input, but this technology is still in development and decades away from being available to the public. For the foreseeable future, drivers must be properly trained and prepared to use these vehicles to navigate roadways safely, including being able to swiftly take over the driving task with limited notice. Additionally, educational strategies designed to meet the needs of specific driving populations, such as older drivers, are essential to the success of these initiatives.

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[1] NHTSA 2013
[2] Hedlund 2018; Robertson et al. 2016; Robertson et al. 2018
[3] Robertson et al. 2018
[4] Robertson et al. 2016
[5] Eriksson & Stanton 2017
[6] Robertson et al. 2018
[7] Eriksson & Stanton 2017
[8,9] Gomes 2014
[10] Shladover 2014

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