AUTOMATED VEHICLES

Introduction to the Use of Automation in Vehicles

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Automated vehicles integrate a varying degree of technology and computing software to support or perform elements of the driving task. Presently, vehicles with limited automation (e.g., Level 1 and 2 automation) are available for purchase and most newer vehicles on the road have some automated features which support the driving task. However, the driver remains responsible for the safe operation of the vehicle at all times. Vehicles with higher levels of automation, in which an automated system can perform the driving task under certain circumstances without human input, are not available to the public for purchase and remain in development and testing phases.

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Questions & Answers

How are the different levels of automation defined?

The Society of Automotive Engineers (SAE) has defined six levels of driving automation in vehicles.[1] Each level is described below along with relevant examples of the technology.[2]

- **No automation:** Corresponding to SAE Level 0, these vehicles require the driver to perform the entire driving task including steering, braking, accelerating, and negotiating traffic as necessary.
- **Driver assistance:** Corresponding to SAE Level 1, these vehicles are equipped with advanced driver assistance system (ADAS) features. ADAS is a set of electronic systems that support the driving task to enhance safety and help prevent collisions. Vehicles with this level of automation offer either steering or acceleration/braking support under certain conditions, but the human driver must remain attentive and perform the remainder of the driving task including monitoring and responding to the driving environment. The driver is responsible for the safe operation of the vehicle. For example, this level of automation is responsible for controlling either the steering or the vehicle speed, but not both simultaneously. The driver performs all other aspects of the driving task and is fully responsible for monitoring the road.
- **Partial automation:** Corresponding to SAE Level 2, these vehicles are equipped with ADAS features, offering both steering and acceleration/

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braking support under certain conditions, but the human driver must remain attentive and perform the remainder of the driving task including monitoring and responding to the driving environment. The driver is responsible for the safe operation of the vehicle. For example, a vehicle equipped with lane centring and adaptive cruise control would support a driver, however, the driver must be ready to perform the driving task at all times.

- **Conditional automation:** Corresponding to SAE Level 3, this is the first category equipped with an automated driving system (ADS), which is an integrated set of automated systems operating simultaneously to perform certain automated driving features. The ADS can assume the complete driving task under limited conditions, including simultaneous acceleration/braking and steering, however the driver must be ready to resume driving at any point should the ADS hand over control when it encounters a potentially hazardous situation it cannot handle. Driving environments outside the operational limits of ADS are the responsibility of the human driver. For example, a semi-automated vehicle could steer, accelerate or brake on a congested highway, but would hand over control to the driver upon encountering a construction zone.
- **High automation:** Corresponding to SAE Level 4, the ADS of this vehicle can handle all driving tasks without human input, but only under specific driving conditions and environments. The ADS is constrained and only able to operate within the boundaries of a pre-defined area on certain types of roads. For example, a shuttle or driverless taxi with high automation would be limited to low speeds and fair weather along prescribed routes or on dedicated roads where no less protected road users (e.g., pedestrians, cyclists) are present.
- **Full automation:** Corresponding to SAE Level 5, the ADS of this vehicle can handle all driving tasks without human input, under all types of driving conditions and environments. Due to the challenges associated with achieving this level of automation, this technology is considered a long-term goal and it will be decades before these types of vehicles are used by Canadians. For example, if such a vehicle were ever developed for public use, it would likely have no steering wheel or pedals.

What level of vehicle automation is presently available?

Many of the vehicles currently available for purchase and on the road are equipped with driver assistance or conditional automation corresponding to SAE Level 1 or 2 automation (i.e., equipped with Advanced Driver Assistance Systems or ADAS). ADAS supports the driving task to enhance safety and help prevent collisions using a combination of sensors and computer software to automate and enhance elements of the driving task. These technologies aid the driver in various ways, such as warning the driver of an unsafe lane change or a possible collision, and automatically applying the brakes to reduce the severity of the impact. ADAS-equipped vehicles are legally permitted on public roads. The safe operation of ADAS-equipped vehicles remains the responsibility of the driver as the technology is designed to offer assistance only. These systems are not designed to replace an attentive and engaged driver.

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Vehicles with higher levels of automation (conditional automation and high automation corresponding to SAE Level 3 and 4) are under development and not available for purchase in Canada. These vehicles have an automated driving system (ADS), which is an integrated set of automated systems operating simultaneously to perform all aspects of the driving task, but only under conditions or environments outlined by an operational design domain (ODD).[3] An ODD defines where (types of roads, speed range, geographic location) and under what conditions (daylight/nighttime, weather limitations) the ADS can safely operate. It will not function outside of these constraints. For example, a vehicle with conditional automation would be able to assume the complete driving task during a traffic jam on the highway but the ADS would not operate outside of these circumstances. There is also a designated fallback when the limits of the ODD have been reached. In vehicles with conditional automation, the fallback is the human driver. This means the driver must be ready at all times to resume driving at any point should the ADS hand over control when it encounters a potentially hazardous situation it cannot handle. The fallback of a vehicle with high automation would likely not require human intervention, but once the operational limits were reached, the ADS may bring the vehicle to a controlled stop in a safe area or, should it require assistance, potentially relinquish control to a remote human driver if no driver were present or if the driver were unable or unwilling to take control.

Beyond this, vehicles with full automation (SAE Level 5) would theoretically be able to perform all driving tasks under all conditions and environments and would likely not have a steering wheel or pedals. However, this level of automation faces many technical and logistical challenges that are far from being resolved. It is therefore considered a much longer-term goal as the widespread use of this technology is estimated to become available decades in the future.

Is a connected vehicle the same as an automated vehicle?

A connected vehicle is not the same as an automated vehicle. A connected vehicle uses wireless networks to communicate with its environment. Current vehicles have some degree of connectivity with vehicle occupants and internet-based applications.

Connectivity with the other vehicles and transportation infrastructure is also possible and is known as vehicle-to-vehicle communication and vehicle-to-infrastructure communication. Vehicle-to-vehicle communication can help alert surrounding vehicles to an issue ahead, signalling other vehicles to slow down and proceed with caution. Vehicle-to-infrastructure communication can provide vehicles with detailed and real-time navigation information. As this technology slowly comes to market, the increasing connectivity of vehicles can enhance their safety and efficiency.

Eventually, it is expected connected vehicle technology can complement automated vehicles as higher levels of automation become available, allowing automated vehicles to communicate more efficiently and share data about the driving environment. Connected automated vehicles could also help improve the flow of traffic and significantly reduce congestion.[4]

Conclusion

In summary, vehicles with driver assistance and partial automation (i.e., Level 1 and 2) are currently available for purchase, but higher levels of automation with the capacity to assume all aspects of the driving task do not yet exist. As higher levels of automation become available, automated driving systems will have the capacity to assume the driving task only under certain pre-defined conditions and environments, and the human driver will be responsible for the safe operation of the vehicle outside of these limits. Ultimately, a vehicle with full automation will theoretically not require a human driver and will likely not have a steering wheel or pedals. However, this level of automation is decades away as there are many technical and logistical challenges to be resolved before this becomes a reality.

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[1] SAE J3016 standard
[2] NHTSA 2017; Transport Canada 2019
[3] NHTSA 2017
[4] Transport Canada 2019

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Traffic Injury Research Foundation

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Traffic Injury Research Foundation (TIRF)
171 Nepean Street, Suite 200, Ottawa, ON K2P 0B4
Email: tirf@tirf.ca

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