Volume 29, Number 1
ISSN: 0886-9685

Civil Engineers and Automated Vehicles: A Primer for the Civil Engineering Community

William Lyons[1]

[1] President and CEO, Fort Hill Companies LLC

Email: wlyons@forthillcos.com

Abstract

The subject of automated vehicles is omnipresent in current events and in the press. Automated vehicles are nascent in their development and adoption, and yet they are poised to revolutionize the way we conceptualize our transportation infrastructure. A critical goal of this article is to inform colleagues and practitioners why they should care about automated vehicles and their impact on our industry. For the practitioner who does not practice in this area, this article offers a primer on automated vehicles.

Keywords: automated, vehicles, transportation, mobility, infrastructure

1. What Are Automated Vehicles?

First, it is worth mentioning what does not qualify as an automated vehicle. The technologies that constitute automated vehicles do not include connected vehicles, vehicle-to-vehicle infrastructure (V2i), vehicle-to-other infrastructure (V2x), or the multitude of intelligent transportation system (ITS) applications currently in use. The term automated specifically applies to vehicles that act in an automated manner, or without any input from external systems. However, as a practical matter, most experts believe that automated vehicles will not be completely automated, especially in cities, where the benefits of communicating with other vehicles and infrastructure (and even people) can help realize the potential of Vision Zero.

So, what is an automated vehicle? In short, an automated vehicle is a vehicle that is capable of navigating without human input by using sensors and global positioning systems (GPS). The sensors typically include stereo vision cameras, LIDAR (Laser Imaging, Detection and Ranging), and an inertial measuring unit (IMU). The expectation is that a fully automated vehicle can successfully navigate any driving environment without human input.

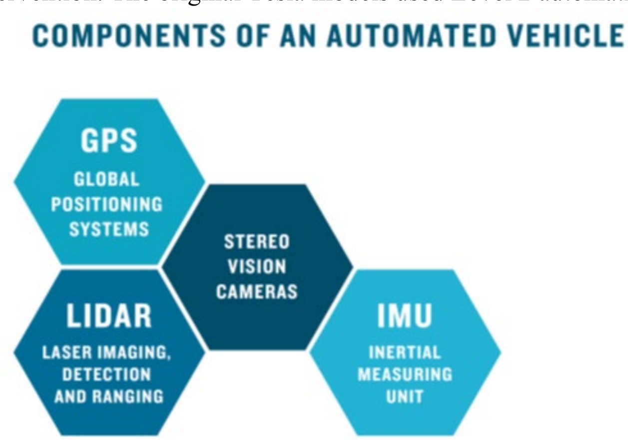
1.1 Levels of Autonomy

According to the Society of Automotive Engineers (SAE), a standard which has been broadly adopted across the industry, there are five levels of autonomy.

A Level 0 automated vehicle is a car with no automation. This is today's no-frills, base purchase automobile. Level 0 vehicles may have cruise control, as long as the cruise control is not dynamic. In other words, if a car has variable cruise control that adjusts to the speed of traffic in front of it, it is not a Level 0 vehicle, it is a Level 1 vehicle.

A Level 1 vehicle is a motor vehicle that has some aspect of dynamic automation. This typically includes steering and speed (acceleration/deceleration). A vehicle that uses a parking assist system or has dynamic cruise control would be a Level 1 vehicle.

A Level 2 vehicle is a motor vehicle that has both steering and acceleration/braking control. A Level 2 vehicle uses automation for both steering and speed control, with the potential for driver intervention. The original Tesla models used Level 2 automation.



A Level 3 vehicle operates under conditional automation. As long as a vehicle is operating within set parameters, it operates under automation. If certain conditions are met, the driver must resume control of the vehicle. For instance, weather conditions might render the sensors of the vehicle unable to perform as designed, and the driver might have to resume control. General Motors and Tesla both make vehicles that are capable of Level 3 automated operation.

A Level 4 vehicle is a fully self-driving vehicle operating through automation in areas where it has been designed to operate. For instance, most of these vehicles have been specifically designed based on the mapping of roadways and other infrastructure, which assist in the guidance of the vehicle. Think of this as the automated vehicle following Google Maps directions. However, if the vehicle is operating outside of map range, it will not be able to operate automatedly. It must be operated by a human in these limited circumstances. This is what defines a Level 4 vehicle versus a Level 5 vehicle.

A Level 5 vehicle will operate in automated mode anywhere, under any conditions. This includes extreme weather conditions, off-road conditions, and in areas with no satellite or cell reception to help guide the vehicle. It is expected to operate completely independently of human inputs, other than establishing destinations and waypoints.

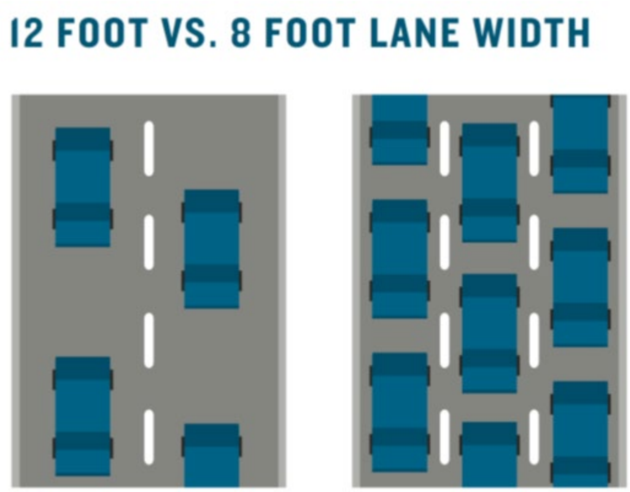
SAE FIVE LEVELS OF AUTONOMY

LEVEL	NAME
0	no driving automation
1	driver assistance
2	partial driving automation
3	conditional driving automation
4	high driving automation
5	full driving automation

2. Why Should We Care About Automated Vehicles?

Now that we know what automated vehicle are, why should civil engineers be interested in them? The answer to this question lies in the long-term impacts of automated vehicles on roadway design, traffic flow, safety, equity, land use, and the very existence of the automobile as we know it. Let's pull apart some of the key issues and potential impacts associated with automated vehicles.

Regarding roadway design, the design features related to traffic control, vertical and horizontal geometry, and lane width will all be dramatically changed. Once fully adopted, automated and connected vehicles will no longer need traffic signal indications or sign legends, because the vehicle will be communicating with roadside technology that will tell the vehicle when to slow down, when to stop, and when to obey other traffic requirements. Roadway geometries and lane widths can be dramatically changed because automated vehicles will not be capable of speeding and will not deviate in their lane. Smaller vertical and horizontal curves can be used, and much more narrow lanes – perhaps as narrow as 8 feet in most cities – can be adopted.



Traffic flow will also dramatically change. Automated and connected vehicles are expected to operate at significantly smaller headways – as little as ten feet at highway speed. As stated above, they could operate in lanes as narrow as 8 feet, allowing for an additional travel lane on a highway that currently has three 12-plus foot lanes. The effect of this is to substantially increase vehicle capacity. One research study suggests that the capacity of highways could increase by as much as 100% and freeway travel speeds could increase 20% (Sundquist, 2016). Some prognosticators (including myself) have suggested that this will effectively merge highway and transit modes into one transit system – the so-called "transportation theory of everything."

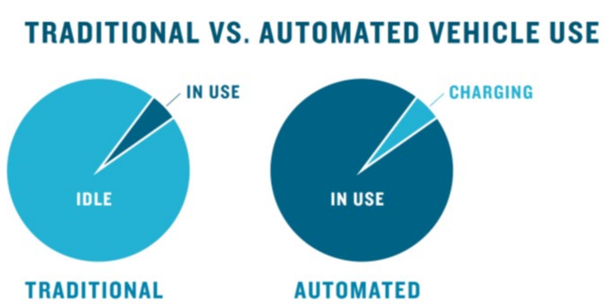
Perhaps the greatest promise of automated vehicles is safety. Automated and connected vehicles have the potential to put Vision Zero in reach. Vision Zero is the transportation planning and engineering goal of having zero deaths due to motor vehicle crashes. Vision Zero began in Europe and has become a goal in the United States. It is now a worldwide movement.

By eliminating human error (think distracted driving, impaired driving, fatigued driving, and aggressive driving), and equipping vehicles with sensors that will proactively prevent crashes, it is possible to eliminate virtually all crashes. There will still be occasional crashes due to malfunctions and glitches, but there would be far fewer accidents. In fact, the manufacturers of automated vehicles have already said that they are going to self-insure their vehicles, which portends an ominous outlook for the automobile insurance industry and the auto body repair industry.

There are many pros and cons of the safety aspect of automated vehicles from an economics point of view, but from a safety point of view, automated vehicles are good news. Imagine a world without the 33,000 highway deaths annually in the United States. In addition to the many lives saved, the reduction in lost productivity, and the virtual elimination of property damage, we could possibly eliminate almost all highway incidents from crashes that result in significant congestion on our highways. These would be tremendous benefits for society and the transportation community.

Another big winner in the automated vehicle revolution is disadvantaged populations. The physically disabled, the mentally disabled, the aged and infirm, and children will all benefit. These populations are currently restricted (on some level) from driving. The automated vehicle will level the playing field for these groups and create equity for these populations.

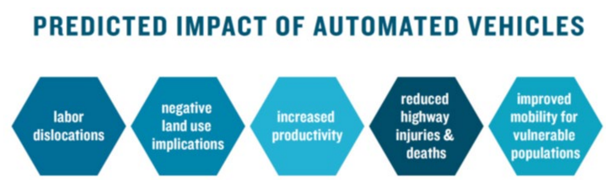
The automated vehicle is also likely to have a very substantial impact on land use. For instance, if your automated vehicle drops you off at your office in the morning, and circulates all day working for Uber, will parking garages in urban settings be needed or economical? Today, most cars in the United States are operated 5% of the time. In an automated vehicle world, vehicles will be in use 95% of the time, and the rest of the time they will be at a charging station. As a result, structured parking garages will become uneconomical and will be redeveloped (either through demolition or adaptive reuse) for higher and better forms of land use, such as housing or office.



In addition, if your automated vehicle can drive you to work three hours from your house, and you can work, rest, or socialize during that drive with no responsibilities for driving, will people be inclined to live further away from their work location? If this occurs, we could induce a whole new generation of sprawl, in the same manner that the interstate highway system induced sprawl and created a whole new world of suburbia. This would be a highly negative and unsustainable land use consequence of automated vehicles.

3. What Are the Long-Term Implications of Automated Vehicles?

Emerging research and debate have suggested that the combination of automated vehicles, the sharing economy, and electric vehicle technology will hasten the end of the internal combustion engine by 2030. This would be a very significant development, as it would have substantial benefits for air quality and climate change. The benefits of eliminating the internal combustion engine in favor of all electric vehicles (powered by renewal energy) would be game-changing.



This confluence of automated vehicles, shared vehicles, and electric vehicles would result in automobiles effectively becoming available on a prescription or a fractional basis. This model is called Mobility as a Service (MaaS) or Shared Electric Automated Mobility (SEAM). Instead of each person owning a car, they will subscribe to a car plan that offers them a set number of hours per week or month. The subscriptions will be offered directly by the car manufacturer, which will maintain the vehicle, insure the vehicle, fuel the vehicle, and store the vehicle (when not operating). This model of car "ownership" is predicted to save every American more than $5,000 per year. It also provides tremendous equity and opportunity for lower income populations in need of mobility options.

On the downside, the MaaS model will radically change the nature and profitability of automobile manufacturers, and will likely bankrupt fossil fuel companies due to stranded extraction and refinery assets. This is to say nothing of the automobile manufacturing and repair workforce, as well as the fossil fuel workforce. However, the model is unavoidable, as some car manufacturers are already offering subscriptions, and the three trends are already converging, with Uber entering the automated and electric vehicle markets.

3. Conclusion

The automated vehicle represents a very serious disruptive force for our entire society. Many positive and negative impacts are predicted, as is the case with any technological disruption. There will be many labor dislocations and there could be very negative land use implications. There will also be significant benefits to society in terms of increased productivity, reduced highway injuries and deaths, and improved mobility for vulnerable populations.

It is not a matter of “if” automated vehicles happen (or MaaS for that matter). It is a matter of when. Some modelers (such as Tony Seba, see https://www.rethinkx.com/headlines) predict that it will all become mainstream by 2030. Others say it will take 50 years or more. In truth, no-one knows. However, considering it usually takes decades to plan and execute major infrastructure projects, we as a profession must incorporate planning for automated vehicles into our projects today, so that the infrastructure will be ready for a whole new tomorrow.

References

Sundquist, Eric, *Automated Vehicles Will Bring Big Highway Capacity Increases,* State Smart Transportation Initative, December 2016.