Automation White Paper

By now, many of us have seen a video of a self-driving car that cruises down the road while its passengers read or tap away on their devices. But how close is this to reality?

What is an Autonomous Vehicle?

Autonomous (also known as self-driving, driverless, or robotic) vehicles (AV) are vehicles in which some aspect of vehicle control is automated by the car. Innovations in AV may fundamentally transform how the current transportation system works. These vehicles have the potential to increase safety, improve mobility, and reduce environmental impacts on a global scale. The United States Department of Transportation (USDOT) Intelligent Transportation System Joint Program Office (ITS JPO) has made *Advancing Automation* one of its two key strategic priorities moving forward to help ensure that these future benefits are realized.

Many vehicles on the market today already include some level of automation, such as adaptive cruise control, lane-keeping assistance, and parking assist, with more features expected in the next year or two. In a preliminary statement of policy, the National Highway Traffic Safety Administration (NHTSA) provides a five-part formal classification system for AV[i].

- Level 0: The human driver is in complete control of all functions of the car.
- Level 1: A single vehicle function is automated.
- Level 2: More than one function is automated at the same time (e.g., steering and acceleration), but the driver must remain constantly attentive.
- Level 3: The driving functions are sufficiently automated that the driver can safely engage in other activities.
- Level 4: The car can drive itself without a human driver.

This classification, which focuses on the degree of human intervention needed, provides a framework for understanding advances in AV technology.

Autonomous Vehicle Benefits and Impacts

The potential benefits from AV technology are profound, particularly in the area of safety. A 2015 report from NHTSA estimated the total economic cost of U.S. crashes at approximately $242 billion or $784 for each of the 308.7 million people living in the United States[ii]. This cost includes lost productivity, medical costs, legal and court costs, emergency service costs, insurance administration costs, congestion costs, property damage, and workplace losses. AV technology has the potential to reduce or even eliminate vehicle-based crashes and fatalities caused by human error. The U.S. alone suffered 30,057 fatal crashes in 2013[iii], and over 90% of those fatal accidents were attributable to human error such as not properly checking surroundings, using excessive speed, and general inattention to the roadway.

AVs will be a significant enabler of the new Mobility on Demand (MOD) transportation model in urban areas. MOD will change the current model of the multi-car household to a single or even no-car household as users gradually switch over to services that provide vehicle trips on demand. Under this new model, fewer cars would be required to service the same number of people, reducing the staggering 111 hours of annual per-driver hours wasted in traffic congestion[iv]. These fundamental changes to the transportation system have the potential to improve overall mobility and reduce environmental impacts, including energy use when there are fewer people on the road for less time.

With AV, vehicles will be able to be parked at remote locations or in high-density facilities, reducing the need for many of the parking lots used today. It is estimated that the future AV fleet will require just 75 percent of the space we now reserve for parking our cars[v]. In addition, automation will allow for roadway facilities to run at close to full capacity, reducing the need for more roadway construction and dropping the overall cost of maintaining of the U.S. roadway facilities.

New research programs in AV technologies continue to be launched, creating significant discoveries and improvements in positioning, navigation, timing, mapping services, human factors, sensors, robotics, and artificial intelligence.

The Private Sector's Role in Developing Vehicle Automation

Currently, many private-sector automakers, universities, and technology companies are seeking to promote their expertise and expand into growing AV technology markets. This inflow of research has accelerated the development of AV technologies to the point that several high-end vehicle models now have new AV technologies already built into them, including adaptive cruise control, lane tracking radars and steering, GIS location, and even some limited self-driving capabilities.

Google's Self-Driving Car project started in 2009 and has made substantial progress in the area of AV technology and testing in real world scenarios. To date, the 23 vehicles in its self-driving car have traveled over 1 million miles on U.S. roads in Texas and California with only 14 minor traffic accidents[vi]. These 14 accidents, according to Google, have all been attributed to external drivers' errors as opposed to errors caused by the self-driving system. In light of these results, in 2014 Google changed the design of its self-driving car by removing the driving wheel and the pedals, doing away with the driver's ability to control the vehicle at all. This changed the role of the driver to that of a simple passenger.

BMW, Toyota, Audi and Volkswagen are just a few of the car manufacturers that are making substantial progress in AV technologies. In October 2015, Tesla released beta software for its Autopilot technology which when engaged controls both the speed and the driving of a car. Autopilot will be the first level 2 autonomous system to be used by the general public. However, it still requires drivers to be accountable for anything that happens to the vehicle while in Autopilot mode.

Autonomous Vehicle Timeline

Creating a detailed timeline for autonomous vehicles can be difficult as there are several challenges that will need to be addressed in the areas of technology and policy. Level one automation is already available in some vehicles and, as noted previously, Tesla has released a level two autonomous system. This level two system is still in a beta stage and will require additional testing before it will be ready for everyday use.

Level three automation is still several years away from realistic deployment; the technology needs to mature and undergo testing, and many policy questions must be addressed. Finally, level four automation, a fully autonomous vehicle, is still theoretical and requires significant progress in several areas of research, including human factors, policy, and general user acceptance. With these considerations in mind, it is too early to determine the timing of a public deployment, although concentrated research efforts conducted by the private sector, universities, and the USDOT and its partners could accelerate development and deployment for this level of automation.

Vehicle Automation Challenges

For AV to continue to advance there are many hurdles that must be cleared. The complex tasks of testing, certifying, and assuring the safety of AV technology must be completed. Before AVs can enter mainstream use on U.S. roads, the general public needs to know that the technology is safe to use. Large-scale testing of the resiliency of the system through multiple different scenarios as well as certification of the system to proven safety standards is necessary before AV technology will be accepted by the public.

In the early stages of AV deployment, drivers will still need to be aware of everything the vehicle is doing should the system fail and they need to take control. The transition from passenger to driver in critical situations is a complex human factors problem where the passenger must stay focused on what is going on even when not controlling the operation of the vehicle.

With so much information required to create a fully autonomous system, data privacy and security concerns will also need to be addressed. Users of the AV system will need to know that their information is safe and will not be shared without their consent.

Challenges in varying state regulations and the need for greater consistency across the U.S. will need to be resolved. The same AV working in one state will need to work in another state using similar technology. This requires harmonization of regulations and standards to create a single unified AV system that can be used across the U.S.

Finally, the issue of how automated vehicles will interact within a connected vehicle environment must be considered. The USDOT is working toward the goal of connected automation, where automated vehicles take advantage of CV technology to obtain greater situational awareness. Combining AV with connected vehicles technology extends autonomous systems by taking advantage of connected vehicle real-time communications to support requirements of keeping drivers alert during level 2-3 automation and also increases the range of critical AV applications like queue warning. The National Highway Traffic Safety Administration (NHTSA) has already begun working on a regulatory proposal to require connected vehicle technology devices in light vehicles, with plans to follow up with a similar ruling for heavy vehicles.

USDOT Role in Vehicle Automation

The Federal government serves a critically important role concerning the resolution of the technical and policy challenges pertinent to AV technology. The focus of the USDOT's autonomous vehicle research is the advancement of the technology and systems that will enable the smooth and safe introduction of automated features into the Nation's vehicles and transportation systems. This work includes understanding the enabling technologies, safety assurance, transportation system performance, testing and evaluation, and policy and planning. In addition, the five program categories[vii] (Connected Vehicle, Enterprise data, Interoperability, Emerging Capabilities, and Accelerated Deployment) outlined in the *ITS Strategic Plan 2014-2019* will all contribute to solving these challenges.

In January 2016 USDOT unveiled policy guidance that updates the National Highway Traffic Safety Administration's (NHTSA) 2013 preliminary policy statement on autonomous vehicles. The new guidance reflects the reality that the widespread deployment of fully autonomous vehicles is now feasible.

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[i] http://www.nhtsa.gov/About+NHTSA/Press+Releases/U.S.+Department+of+Transportation+Releases+Policy+on+Automated+Vehicle+Development

[ii] http://www-nrd.nhtsa.dot.gov/pubs/812013.pdf

[iii] http://www-fars.nhtsa.dot.gov/Main/index.aspx

[iv] http://inrix.com/press/americans-will-waste-2-8-trillion-on-traffic-by-2030-if-gridlock-persists/

[v] http://www.mckinsey.com/insights/automotive_and_assembly/ten_ways_autonomous_driving_could_redefine_the_automotive_world

[vi] https://www.google.com/selfdrivingcar/

[vii] http://www.its.dot.gov/strategicplan/