U.S. Department of Transportation
Federal Highway Administration

December 2016

Environmental Justice Considerations for Connected and Automated Vehicles

Connected vehicles (CVs) and automated vehicles (AVs) are two rapidly emerging technologies with the potential to transform our communities and transportation system on a larger scale than anything we have seen since the construction of the U.S. Interstate Highway system. These technologies have justifiably led to high expectations for increased safety and mobility. CVs and AVs also hold strong promise to address the transportation needs of environmental justice (EJ) populations, but barriers to access may affect the full realization of the technologies' benefits.

The Federal Highway Administration (FHWA) defines EJ populations as low-income populations or minority populations who will be affected similarly by a proposed program, policy, or other activity funded by FHWA. As policy discussions, planning, and implementation for CVs and vehicle automation proceed, decision-makers should consider equity concerns and pursue policies to ensure that EJ populations do not experience disproportionately high and adverse human health or environmental effects. Adverse effects may include the denial of, reduction in, or significant delay in the receipt of benefits of FHWA programs, policies, or activities (FHWA Order 6640.23A).

Figure 1: Connected vehicles enable cars to "talk" to one another and this can help to mitigate crashes. (Source: ITS-JPO)

What are Connected and Automated Vehicles?

CVs and AVs refer to two distinct technologies that could potentially work cooperatively. Limited deployment of these technologies has begun and is expected to become widespread over the next 10 to 20 years.

Connected Vehicles

CV technology will enable cars, trucks, buses, and other vehicles to "talk" to each other, to infrastructure (traffic signals), and with other road users (pedestrians with compatible smartphones, for example) using built-in or add-on devices that continuously share important safety and mobility information. CV technology enables communications among vehicles, infrastructure, and personal communications devices operated by passengers, pedestrians, bicyclists, or other road users.

Figure 2: Graphic illustrates continuous communication between a blind pedestrian's smart phone, traffic signal and automobile. (Source: ITS-JPO)

There is also ongoing research using CV data and technology to improve traffic safety on mixed-use roadway networks such as the Pacific Northwest Transportation Consortium (PacTrans) study on [Enhancing Safe Traffic Operations Using Connected Vehicles Data and Technologies.]

While many existing wireless technologies can support a range of CV operations, including cellular networks and Wi-Fi, safety-related systems for CV technology will likely be based on dedicated short-range communications (DSRC), a technology similar to Wi-Fi but optimized to be fast, secure, reliable, and not vulnerable to interference.

Non-safety applications may be based on DSRC or on other types of wireless technology. The transmitted vehicle information does not identify the driver or vehicle, and the technical controls have been put in place to help prevent vehicle tracking and malicious tampering with the system. CV technology may provide potential safety and mobility benefits to all roadway users, including the following:

- Improved collision avoidance
- Ability to detect and/or warn suitably-equipped pedestrians and bicyclists of approaching vehicles
- Ability to interact with traffic signals (report on signal phase, request activation)
- Ability for suitably-equipped users to request a bus stop, or be notified of an approaching bus

Automated Vehicles

AVs operate at least some aspect of a safety-critical control function (e.g., steering, throttle, or braking) that occurs without direct driver input. AVs may use only conventional on-board vehicle sensors or may also be connected (i.e., use communications systems such as CV technology, in which cars, roadside infrastructure, and other roadway users communicate wirelessly). Vehicle connectivity is important to realizing the full potential benefits of AVs.

Levels of Automation

Vehicle automation is not “all or nothing.” Fully automated vehicles (“self-driving cars”) are at the far end of the spectrum but more limited automation may also provide significant benefits. The SAE International has defined vehicle automation in six levels (numbered 0 through 5), as described in the sidebar.

Levels of Automation

USDOT and NHTSA use automated vehicle classifications developed by SAE International (SAE J3016):

At SAE Level 0, the human driver does everything;

At SAE Level 1, an automated system on the vehicle can sometimes assist the human driver to conduct some parts of the driving task (e.g., adaptive cruise control);

At SAE Level 2, an automated system on the vehicle can actually conduct some parts of the driving task, while the human continues to monitor the driving environment and performs the rest of the driving task (e.g., combined lane centering and adaptive cruise control);

At SAE Level 3, an automated system can both actually conduct some parts of the driving task and monitor the driving environment in some instances, but the human driver must be ready to take back control when the automated system requests;

At SAE Level 4, an automated system can conduct the driving task and monitor the driving environment, and the human need not take back control, but the automated system can operate only in certain environments and under certain conditions; and

At SAE Level 5, the automated system can perform all driving tasks, under all conditions that a human driver could perform them.

Using the SAE levels, USDOT draws a distinction between Levels 0-2 and 3-5 (“highly automated vehicles”) based on whether the human operator or the automated system is primarily responsible for monitoring the driving environment.

Source: Federal Automated Vehicles Policy (September 2016)
https://www.transportation.gov/AV

Potential Benefits of Automation

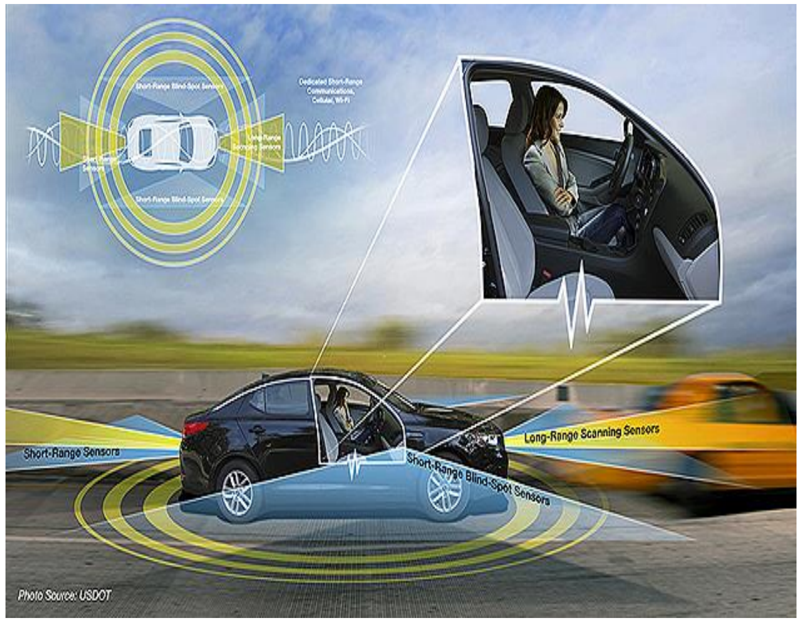

Figure 3: Automated vehicles use on-board sensors, cameras, global positioning, and high-precision mapping to help perform safety-critical driving functions such as steering, acceleration, and/or braking. To ensure full awareness of their surroundings, automated vehicles can leverage connected technology to communicate wirelessly with other vehicles and roadside infrastructure. (Source: ITS-JPO)

Significant improvements in traffic safety and operational efficiency are anticipated through applications of AV technology even at lower levels of automation, especially if the vehicles are connected and can respond automatically to roadway conditions reported by roadside equipment or other roadway users. Full automation at Level 5 can potentially deliver even more significant benefits, by entirely removing the need for a human driver.

Vehicle automation provides many additional benefits beyond those provided by CVs. Automated vehicles will not necessarily be implemented with connected vehicle technology, but the benefits of automation will be even greater if the vehicle is connected as well as automated.

Expected benefits include:

- Safety benefits due to reduced risk that driver inattention or distracted driving will cause crashes;
- Fully self-driving vehicles can provide mobility for populations unable to drive;
- Provision of taxi and transit service can be much less expensive and more reliable if vehicles are automated;
- The line between “fixed route” buses and paratransit can blur considerably if AVs are used;
- Vehicle parking needs may be reduced if vehicles can be dispatched automatically for other riders;
- Environmental benefits may accrue as cars harmonize their speeds through traffic signals without stopping; and
- Mobility could be increased by allowing greater coordination of traffic and responsiveness of vehicles.

What Might Connected and Automated Vehicles Mean for Environmental Justice?

Both CVs and AVs have the potential to improve safety and quality of service, and lower the cost of providing traditional transit services or transit alternatives such as “shared mobility” (for example, automated taxis or paratransit vehicles). These benefits may be significant for EJ populations. But these technologies may have some risks as well, especially with respect to equitable distribution of benefits and burdens.

Low-income populations, for example, may experience the benefits of CV and AV technology differently compared to other populations, because they may have less access to personal vehicles, live farther from their work places, or have jobs with non-conventional work schedules and limited work location flexibility. Limited access to smartphones or electronic payment methods among EJ populations may restrict use of

AVs offered through car-sharing services or automated taxis. EJ communities may be concentrated in neighborhoods with less well-maintained infrastructure, greater exposure to high-volume roadways, or higher levels of pedestrian activity. While new vehicle technologies may improve safety in those conditions, there is also the potential for negative impact if, for example, lack of infrastructure maintenance impairs the ability of AVs to navigate the infrastructure and operate safely.

Connected Vehicles

The benefits of CV technology depend on installation of, and access to, suitable equipment and infrastructure. Such access may be expensive and not uniformly available to EJ populations. Partial deployment of CV technology may leave "blind spots" in the system which could be distributed inequitably, especially with respect to EJ communities. If EJ communities are overlooked as the technology becomes more widespread, then the safety and mobility benefits of the technology may be delayed or denied in those communities, potentially leaving individuals subject to greater accident risks and traffic congestion. If these issues are not addressed during system planning, CVs may have a disproportionately high adverse effect on EJ communities.

Figure 4: Connected vehicles of all types communicating at a busy intersection.

Automated Vehicles

There are many unknowns with respect to when and where AVs may be deployed commercially, and whether they appear primarily as personal vehicles, in taxi or transit service, or in other fleets. The principal development of vehicle automation technologies is taking place in the private sector, and there are many regulatory and planning issues yet to be addressed as AVs appear in greater numbers. While access to this technology in private vehicles may initially be limited for low-income EJ populations, high levels of automation will potentially make it much less expensive to deliver taxi and transit services to those who cannot afford (or physically cannot operate) a personal vehicle. It is not clear what role public agencies will have in deploying these technologies, what the relationship will be between private "mobility services" and public transit agencies, and what effect such technologies will have on the provision of public transit generally.

Because of the potential both for positive and negative outcomes compared to current conditions, it is very important that the effect of new technologies on EJ populations be carefully considered in policy and planning decisions. Planners and others interested in equitable outcomes will want to pay attention as these technologies move from laboratories and test tracks onto the public roads. They will also need to stay engaged in the public data gathering and evaluation discussion that will be occurring around connected and AVs in the coming years. Development of Strategic Highway Safety Plans (SHSP) presents an opportunity to explore CV and AV technology in relation to potential EJ concerns. Each State is required to consider EJ populations when developing its SHSP (23 U.S.C. 148).

What is FHWA doing to address the issue?

FHWA has various initiatives underway to better understand and respond to potential effects of CVs and AVs on EJ populations. FHWA is conducting research to support access to CV technology for pedestrians and bicyclists via smartphones and bicycle-based hardware, as well as to manage interactions between connected vehicles and roadway users who are not equipped with the technology. The Accessible Transportation Technologies Research Initiative (ATTRI) is a joint initiative that is co-lead by FTA, FHWA, USDOT Intelligent Transportation Systems Joint Program Office (ITS JPO) and other Federal partners. ATTRI leads efforts to research, develop, and implement transformative solutions, applications, and systems to help all people—particularly those with disabilities—effectively plan and execute their travel, by addressing individual mobility needs. Currently, ATTRI is conducting research to improve the mobility of travelers with disabilities through the use of connected vehicle and related technologies.

Improving traditional paratransit and other human service transportation (HST) operations using ITS technologies can help optimize and manage passenger trips for those Americans experiencing mobility challenges. Through the Mobility Services for All Americans (MSAA) initiative, the USDOT fosters partnerships among paratransit service providers, local governments and other public, private, and non-profit assistance organizations to share data and better manage resources to improve mobility options for all. Connected and automated vehicles are expected to be an important element in future transit and paratransit systems, where they have the potential to improve service levels and safety, and to reduce costs.

In December 2015, USDOT launched a national Smart City Challenge and in June 2016, announced Columbus, Ohio as the winner of the Challenge, which includes initiatives to use automated transit vehicles to provide better access to jobs and healthcare and to use vehicle connectivity and other advanced technologies to improve access to the transit system for EJ populations.

USDOT and FHWA are continually engaged in research, resource development, and emerging policies regarding the deployment of CVs and AVs. As policy discussions, planning, and implementation for CVs and vehicle automation proceed, decision-makers should consider equity concerns and pursue policies to ensure that EJ populations are not adversely impacted. Similarly, the benefits of AVs and CVs should be distributed equitably to help address the mobility needs of all people, particularly those who are socially, economically, or mobility disadvantaged.

Below are additional Federal resources and ongoing research regarding considerations for EJ populations and technology interface with multi-modal users associated with connected and automated vehicles.

Federal Resources

The USDOT ITS JPO has published factsheets and other research on the technology and deployment of AV and CV technology on the websites listed below:
Connected Vehicles - http://www.its.dot.gov/research_areas/connected_vehicle.htm
Automated Vehicles - http://its.dot.gov/research_areas/automation.htm
Transportation Planning - http://www.its.dot.gov/research_areas/cv_planners.htm

The National Highway Traffic Safety Administration Federal Automated Vehicles Policy (September 2016) http://www.transportation.gov/av.

The FHWA Environmental Justice website - http://www.fhwa.dot.gov/environment/environmental_justice/ provides information on EJ polices, research, case studies, and resources, and will feature future research on considerations for environmental justice populations and deployment of connected and automated vehicles.