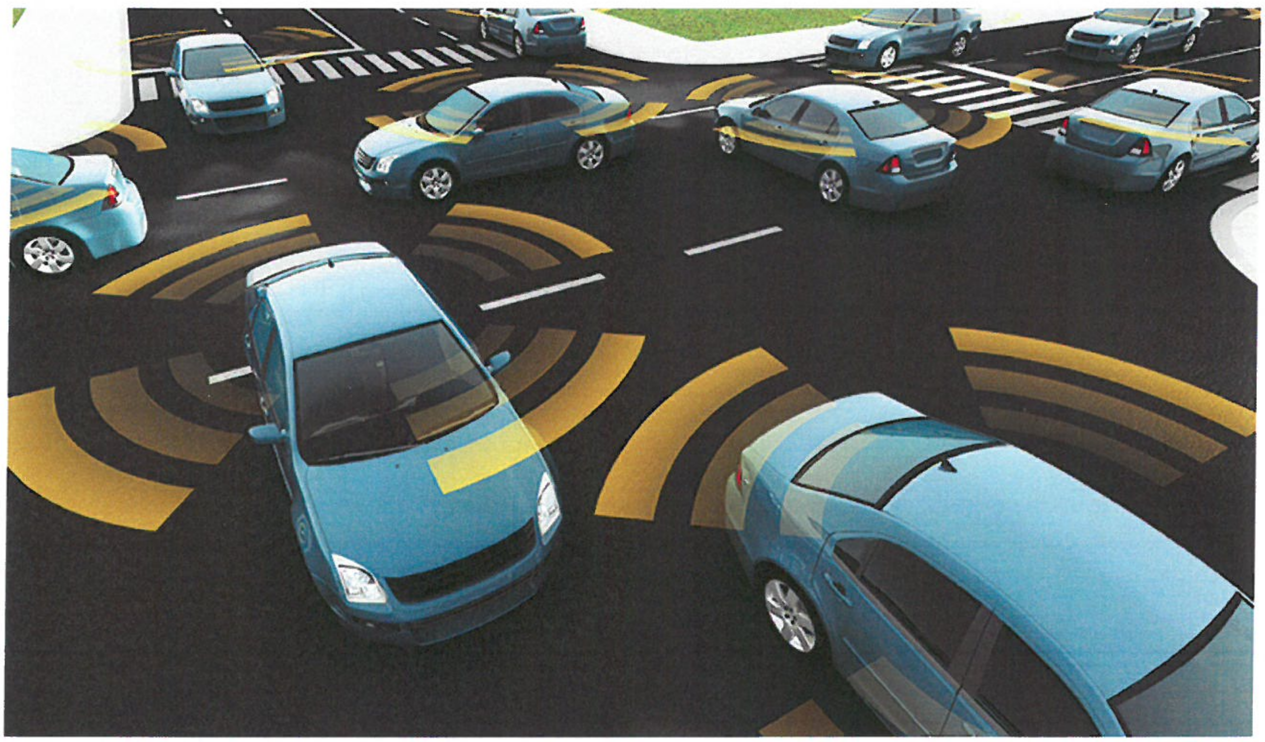
URBANLAND
THE MAGAZINE OF THE URBAN LAND INSTITUTE

Autonomous Vehicles: Hype and Potential

By Peter Calthorpe and Jerry Walters
March 1, 2017



Autonomous cars could achieve efficiencies by communicating with each other and coordinating their movements.

Every new transportation technology affects the geography of communities and the structure of people's lives. Autonomous vehicles (AVs) are one such technology. Just as the freeway system or the streetcar network shaped past cities and lifestyles, AVs will remake the metropolis once again. The question is how and with what unintended consequences? As with most technology, the answer turns on how the technology is used.

Many people believe that shifting to AVs will eliminate vehicles from roads and offer myriad benefits, including improved traffic flow, fewer traffic accidents, and enhanced mobility for the handicapped, elderly, and children. With AVs, people would free themselves from parking hassles, congestion, and many financial and environmental costs. Unfortunately, reaching this outcome is not that simple.

One thing is certain: zero- or single-occupant vehicles—even with AV technology—are a bad thing. They cause congestion, eat up energy, exacerbate sprawl, and emit more carbon per passenger mile. Surprisingly, even AV taxis carrying three passengers can generate more miles because of distant pickups and roaming as they await passengers. And the promise of efficient flow and energy savings can only be delivered in exclusive areas free of non-autonomous vehicles. The best of AV technology is in shared vehicles and a new generation of transit options—AVs used on dedicated lanes or in car-free districts with multiple passengers as an inherent option.

The reality is that some forms of AV could actually make things worse. The convenience of AVs could result in more miles traveled—up to 35 percent more for personal AVs and an amazing 90 percent more for single-passenger AV taxis, according to Urban Mobility: System Upgrade, a 2014 study by the International Transit Forum (ITF) and the Corporate Partnership Board (CPB). This increase is the result of riders acquiring a greater tolerance for long commutes, and vehicles running "deadhead" trips to look for new riders or cheap parking and running errands. The only thing worse than a single-occupant vehicle is a zero-occupant vehicle (ZOV).

With private AVs on the road, the U.S. vehicle-miles traveled (VMT) total is expected to increase by 2 trillion to 3 trillion miles over the next 30 years, according to author calculations based on several data sources—more than five times the increase over the past 30 years when auto use rose dramatically due to suburbanization, women entering the workforce, and inexpensive gasoline. Higher VMT means more road use and, therefore, more congestion and carbon emissions.

These outcomes are not inevitable. Indeed, the impact of AVs on a region will depend on many factors, one of the most important being how AVs are used.

AV technology can be applied in three distinct ways—in private cars, in taxis, and in transit systems—each of which will have different impacts and benefits. Private use will result in more traffic and carbon emissions but will provide convenience, safety—and in all probability a new lease on life for sprawl. Taxis, if shared and used to reach mass transit, are better in terms of VMT, but single-passenger taxi use will increase VMT the most.

In contrast, application of autonomous rapid transit (ART) would use the technology in small express buses and minivans traveling in dedicated lanes or auto-free zones. This would provide low-cost, 24/7 service without squandering miles in ZOVs or suffering the inefficiencies of mixed flow—combining cars, buses, trucks, and bikes in the same lanes. If ART became dominant, it could reduce VMT by 37 percent while eliminating congestion and 95 percent of public parking, according to Shared Mobility; Innovation for Livable Cities, a 2016 ITF/CPB study. In the end, all three types of AV will exist, but in what sequence, in which environments, and in what proportions?

Personal Autonomous Vehicles

Many levels of personal AV technology exist, each with different capabilities and potential. The National Highway Traffic Safety Administration (NHTSA) defines five levels of increasing vehicle autonomy, each of which requires differing capabilities in differing environments. Today, a driver can use the auto-pilot features of a level 3 AV such as Tesla on a freeway, but not easily on city streets. Level 5, full autonomy, will work on a dedicated transit lane before it will work in general traffic. Therefore, timing of AV deployment will depend on the context as well as the technology.

A rendering of Google's self-driving vehicle prototype. (Google)

Another variable is the mix of traffic. AV systems run more safely and efficiently if they are in dedicated lanes where they can travel closer together in "platoons" (reducing the amount of road space occupied) and communicate with each other to coordinate movements through intersections (improving traffic flow). When AVs function in complex mixed environments, their capacity to improve traffic flow by driving close together or coordinating with other vehicles is greatly compromised.

Because of these complications, the rate of adoption of AV technology will affect performance dramatically. Some estimate that driverless vehicles could dominate city streets by 2040; others predict 2060. But the mixed phase will last for some time, and will present a real design challenge.

Counterintuitively, a city with a 50 percent mix of private AVs and traditional vehicles will see its VMT total rise about 20 percent, and VMT will rise about 35 percent with full saturation of AVs, according to the 2014 Fehr & Peers report Effects of Next-Generation Vehicles on Travel Demand and Highway Capacity. The increased VMT is a product of the cars roaming empty to find cheap parking and the tendency of people to tolerate longer trips if they do not have to drive. In addition, people will tend to send their cars on trips they would not normally take—for example, to run an errand or pick up someone. Imagine the implications of an AV drive-through at McDonalds.

Alternatively, on freeways, a 75 percent mix of AVs with traditional vehicles will enhance traffic flow by 25 to 35 percent because of platooning. So personal AVs will be good for suburbs where freeways are common, arterial roads are big enough to handle the increased VMT, and long commutes are common.

Thus, personal AVs could increase sprawl as commutes from distant locations become less irritating and can be transformed into productive time. VMT figures will increase, boosting energy use and carbon emissions even beyond what may be offset by more efficient electric motors or platooning. In the near term in older city centers with complex mixed-flow environments, use of personal AVs will lead to more congestion caused by increased VMT and compromised AV capabilities.

Autonomous Taxis: Single or Shared

Application of AV technology to single-passenger taxis or Uber-like systems, unfortunately, presents many of the same problems as use of private AVs: it would offer few benefits in terms of road capacity in mixed-flow traffic and contribute even more to increased VMT as AV taxis reposition themselves on streets in order to pick up passengers and drive extra ZOV miles for remote pickups.

A prototype of a driverless minibus is tested on the streets of León, Spain. (Sigur/Shutterstock.com)

In addition, short walks or bike trips might be lost to affordable AV taxi rides that are free of parking hassles. On the other hand, availability of AV taxis could reduce household auto ownership, which could lead to lower parking needs along with increased mobility for the elderly, the handicapped, and children.

AV taxis hold complicated promise in urban environments. The Urban Mobility study, which assumed complete elimination of private cars from Lisbon's city center, showed that all current trips could be handled by just a quarter of the city's existing cars. But the penalty would be huge: a near doubling of the total miles driven, once again because of repositioning, circling, and remote pickups—the dreaded ZOV miles.

Factoring in shared rides reduced the added miles to a 22 percent increase, and if the shared taxis brought people to mass transit rather than to final destinations, increased VMT came down to just 6 percent while solving the "last mile" problem for mass transit riders. In addition, trip time would be reduced because, without mixed flow, the AV technology could function at its highest level and reduce congestion through platooning and smart intersection coordination.

These outcomes would be further enhanced by virtual elimination of the need for on-street parking, opening up extra lanes for bikers and more space for pedestrians. Also, parking lots could become sites for infill development, offsetting the need for suburban sprawl.

In sum, shared AV taxis in areas that ban private autos and maintain high-capacity transit service would be a great application of the technology, even if it did not significantly reduce VMT, energy consumption, or carbon emissions.

To be effective, though, AV taxis would need to be shared, avoid mixed-flow streets, and be used primarily for short trips or as feeders to transit. Because the transition to purely AV environments will take time, the best outcomes also will be compromised for decades. And because the private vehicle fleet may never be fully eliminated, this option may never provide its ultimate benefits.

Autonomous Rapid Transit

Autonomous rapid transit proposes the application of AV technology in shared vehicles in dedicated transit lanes similar those used in bus rapid transit (BRT) systems. Such an approach would achieve the efficiency of AV flow without eliminating private vehicles from city streets. It would minimize the operational costs of BRT by eliminating the need for drivers, reduce VMT significantly by tailoring capacity by time and place to match demand, and cut travel time for many passengers by providing direct express service to destinations.

Most important, ART could form a feasible, smooth transition from the existing conditions and ownership patterns to complete shared-AV environments in which all private autos are eliminated.
Shared Mobility, ITF/CPB's update of their seminal 2014 AV study, found that once an urban district eliminates private autos, variations on shared AV minibuses and vans will virtually eliminate congestion and parking and can reduce VMT by 37 percent. This study used a range of shared six-, eight-, and 16-person minibuses and vans coordinated with the existing mass transit resources and walkability of Lisbon. The study assumes that the minibuses and vans could be AVs or driver controlled, and that the outcome would be the same in terms of VMT. The reductions in VMT found in this study are essentially a direct result of the assumed higher vehicle occupancy.

It should be noted that Lisbon's transportation mode share, of which 55 percent is currently transit, walking, and riding bikes, is very different from that in most U.S. cities. It also assumes that because shared AVs would be ubiquitous, traditional bus routes and stations would be replaced by a complex network service efficiently integrating all origin/destination requests. The study effectively represents an end-state performance for ART in which dedicated lanes finally make the transition to AV districts.

A recent unpublished study by Fehr & Peers and Calthorpe Associates looked at replacing buses in a proposed BRT line along a stretch of Geary Boulevard in San Francisco as a first step toward ART. The BRT system is planned to convert two lanes of the six-lane arterial into dedicated bus transit lanes.

The study looked at replacing the buses with a fleet of four-person AVs that would gather at least three passengers before proceeding directly to the destination. In addition to skipping all the typical bus stops along the way to a passengers' destination, the cars would travel in a platoon and trigger green lights at intersections for better traffic flow. The analysis found that such a system would reduce travel time by 35 percent compared with BRT and by 50 percent compared with the private vehicles traveling alongside in the nondedicated lanes.

Such an ART system could be efficient in many other ways. The study found that, with a mix of 20-passenger minibuses and four-passenger AVs, ART lanes would have a peak throughput equal to moderate BRT systems around the world today—2,800 to 4,000 passengers per peak hour. That is more than five times the capacity of a standard automobile-dominated city lane.

More important, during off-peak periods, ART vehicles could respond to specific calls for service, reducing inefficient low-occupancy service and saving energy and operating and maintenance costs while eliminating late-night shutdowns. With a well-mixed fleet of large and small vehicles, ART could operate 24/7 and never run ZOVs.

Perhaps its most important attribute is that ART can attract "choice riders." Often new transit systems attract riders from other transit systems rather than get habitual drivers to give up their cars. But with relative privacy, direct-to-destination service, and shorter travel times, ART could coax drivers out of their cars. In addition, low operating costs would allow a transit agency to provide more service on more streets, further reducing private auto use.

Finally, the ART system has the advantage of being able to function with all the travel efficiencies of AV, but on dedicated lanes on mixed-flow streets. Over time, it would provide an organic progression that expands from dedicated lanes to networks of ART streets, then to ART districts, and ultimately to ART cities.

An ART Future

AV technology ultimately will find its way forward in different forms in different places. The unintended consequences of its use should be kept in mind as policy makers and manufacturers apply these new capabilities.

In both the short and long terms, simulations show that the best application of AV technology is a network of ART lines combined with high-capacity metro transit systems. This will avoid degradation of AV performance due to mixed flow, encourage people to share rides, and prompt drivers to reduce their use of private autos. This can then easily evolve into complete ART districts in which private cars are eliminated.

The urban form that ultimately emerges is compelling: a city with almost no on-street parking, housing that is free of garage costs, abundant pedestrian zones, ubiquitous bike lanes, and no ugly surface parking lots. What's more, each step along the way will improve existing communities.

Peter Calthorpe *is a founder of the Congress for the New Urbanism and a winner of the ULI J.C. Nichols Prize for Visionaries in Urban* Development, *and has been named one of 25 "innovators on the cutting edge" by Newsweek for his work redefining the models of urban and suburban growth in America. With his seminal book The Next American Metropolis he defined transit-oriented development for the first time, and with his recent book Urbanism in the Age of Climate* Change *he showed how smart growth can play a systemic role in reducing carbon emissions while solving a broad range of social, economic, and environmental challenges.*

Jerry Walters *is a principal with the Fehr & Peers transportation consultancy, focused on policy, research, planning, and design of multimodal, new-urbanist transportation for communities in the United States and abroad. He led the studies Demographic Trends and the Future of Mobility and Effects of Next-Generation Vehicles on Travel Demand and Highway Capacity. Published work includes Growing Cooler: The Evidence on Urban Development and Climate Change, published by ULI in 2008.*

For More Information:

- Effects of Next-Generation Vehicles on Travel Demand and Highway Capacity, Fehr & Peers (www.fehrandpeers.com), 2014.
- Urban Mobility: System Upgrade, International Transport Forum (www.internationaltransportforum.org) and Corporate Partnership Board, 2014.
- Shared Mobility; Innovation for Livable Cities, International Transport Forum (www.internationaltransportforum.org) and Corporate Partnership Board, 2016.

SHOW COMMENTS