

## Automated Vehicles Have Arrived: What's a Transit Agency to Do?

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Image: Courtesy NAVYA.

## INTRODUCTION

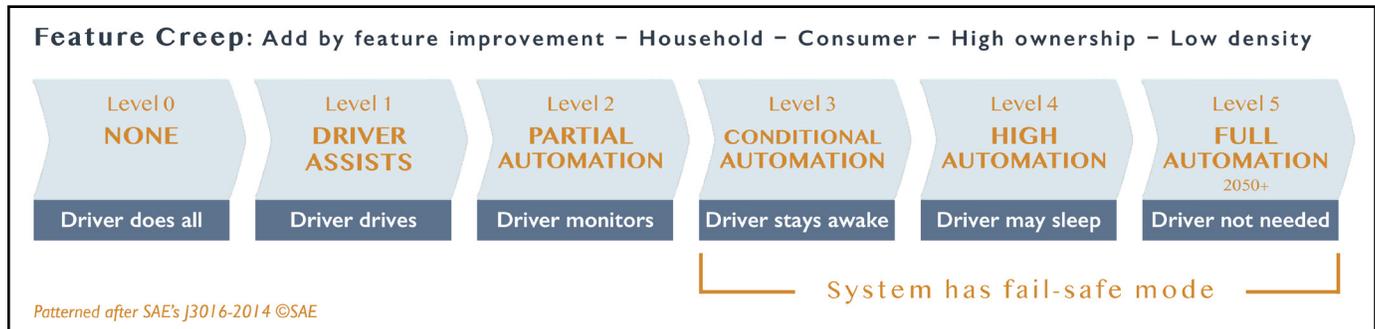
Ongoing innovations in automated and connected road vehicles create a path of radical transformation of personal mobility, the automotive industry, trucking, public transit, the taxi industry, urban planning, transportation infrastructure, jobs, vehicle ownership, and other physical and social aspects of our built world and daily lives.

In considering automated vehicle (AV) deployments and their cost, as well as the changes in traffic volume, congestion, rights of way, and the complexities of mixed fleets with both automated and non-automated vehicles, the time frame of impacts can only be surmised.

Still, it is worth considering a framework for understanding and managing the forthcoming process of change covered in this perspective.

Figure 1 shows a simplified, interpreted version of the Society of Automotive Engineers' (SAE) standardized levels of vehicle automation. These levels represent incremental improvements—feature creep from year to year as new car models are introduced. Incremental innovation

standardizes comparable improvements while engendering interest, excitement, and consumer embrace, all of which fuel more innovation. Feature creep also encourages household vehicle ownership and expansion of motorized mobility across an urban region's widely-dispersed attractions for consumers.<sup>1</sup>



**Figure 1. The SAE Concept of Automated Vehicle Levels**

Note: Diagram by Grush Niles Strategic.

All SAE levels except Level 5 require a human operator in the vehicle. Automated operation rises dramatically at Level 3 and higher. A car at Level 3 can operate in a hands-off mode on a limited access highway with no intersections or driveways. Starting at Level 3, the problem of maintaining driver's attention for taking over control at a planned highway exit or an unplanned emergency that automation cannot handle, becomes acute. At Level 4, long highway segments where a driver can sleep are assumed, and the vehicle systems and the road characteristics need to allow for the possibility of transitioning the car safely at any time from a travel lane to a safe stop on the shoulder. As of 2019, this fail-safe capability has not been demonstrated beyond simple tests.

A road mixture of aggressive human drivers and law-abiding, cautiously moving automated cars is proving to be a challenge even in the relatively simple road environments. Moving Level 5 cars, devoid of steering wheels and brake pedals, present an ever greater challenge in a complex urban environment of traffic lights, non-signalized intersections, curb parking, private driveways, pedestrian crossings, and emergency vehicles. While there is an evolutionary feature-creep path of improved technology and re-engineered roads in advancing from Level 1 to Level 4, the evolution to Level 5, where steering wheels and foot pedals become obsolete in all road and traffic environments, is likely to be decades away for cars sold to consumers, if allowed at all.<sup>2</sup> Robotic, driverless cars on public roads may be regulated into being available only for commercial ride-selling fleets, that is, robotaxis.

The expected path of the evolution from a human-operated to a computer-operated car within the automobile industry is that a licensed operator will remain in control over the ability to turn robotic operation on and off, depending on the road environment. Limited-access highways are relatively easy for computers and sensors to handle at any speed, from full throttle to stop-and-go. Busy city streets and crowded active parking lots are more difficult, and in such places the driver must be ready to steer and brake as usual. The transition from robotic control back to human control when the driver is no longer paying close attention presents a very difficult problem.<sup>3</sup>

## THE NEXT 50 YEARS

Incremental innovation, which is common in consumer product development, adds to the world fleet of automated vehicles one household purchase at a time. As consumers' vehicles with automated capabilities are adopted over the next few decades, the majority of such vehicles will still be at Level 4 or lower, that is, exhibiting automated driver assistance systems (ADAS) with a licensed, responsible operator in control of the moving car. The mixture of SAE levels on the road will create a complex planning environment. Operational deployment of Level 5 vehicles will be required before the most significant anticipated changes start, such as two-minute robotaxi expected arrival times, dramatic reductions in parking needs, and the transition of many professional drivers to other roles. Progress toward Level 5 vehicle autonomy is today exaggerated by careless predictions in North American mass media and widely read social media.<sup>4</sup>

Prior to a high degree of Level 5 penetration, we should expect at least 30 years of mixed fleets of varying levels of semi-automation. Such a long period of time—analogue to the decades experienced in the conversion from all horse-drawn vehicles to all motor vehicles—will be occupied with addressing distracted driving, complex and shifting transit infrastructure planning and street re-organization, temporary right-of-way changes, land-use policy churning, and changing meanings for transit-oriented development.

There are many hurdles associated with constructive deployment of fully autonomous Level 5 vehicles—the technology that gives us robotaxis with no steering wheel and foot pedals at all, lower need for parking, and affordable on-demand point-to-point trips. A Level 5 AV in busy city environments has to handle a large set of difficult and low-probability events on the road. As outlined in the new textbook *The End of Driving* by Grush and Niles,<sup>5</sup> in order to achieve full geographic and socio-economic coverage across urban regions, this kind of automation also needs a body of regulations and incentives implemented via a system of regional harmonization across fleets of multiple service providers.

In the meantime, rather than simply waiting to see what vehicle capabilities evolve from the work of innovators and imitators, proactive transit agencies could and should try to maintain their existing mission by shaping an intentional future for automated road vehicles that serves community needs.

## OWNERSHIP WILL BE DECISIVE

When licensed drivers finally become unnecessary in highly-automated vehicles, car ownership will be the pivotal issue for urban transportation sustainability. Will the majority of passenger vehicles be personally owned household vehicles, or will most of them instead be deployed in publicly or privately operated robotic fleets that sell rides as an alternative to consumers driving themselves?

Popular thinking about the future effects of robotic vehicles often includes the expectation that automation will be total and robotaxi services will dominate urban mobility for economic reasons. Some of this thinking assumes that the current consumer preference for ownership of a personal household vehicle will decline, perhaps even plummet toward zero.

How ownership will settle out after vehicle fleets become fully robotic is now unpredictable. Some scenarios are based on desirable and rational projections that assume wide utilization of highly optimized robotaxi fleets.<sup>6</sup> Other scenarios are based on simulations that start from the current state and recognize that different assumptions about the changes in consumer preferences yield different future states of household ownership—ranging from massive sharing to just a slight increase.<sup>7</sup>

To date, cultural norms, rising household wealth, manufacturing efficiencies, and automobile industry marketing have succeeded in maintaining consumer acceptance of private ownership as the default option. As a result, car ownership is a strong desire throughout the world. However, the sheer number of cars generates environmental concerns because of the fuel consumption, land development requirements, accident rate, and traffic congestion impacts. These impacts remain significant as the vehicle number increases despite the improvements of technological means for reducing crashes, energy consumption, and polluting emissions.

In contrast, the ideal scenario for private transportation companies, such as taxis, shuttle/bus operators and transportation network companies (TNCs) like Uber and Lyft, would be to have all trips taken in one of their vehicles, which are planned and expected to be highly automated in the future and use sustainable energy sources.

While there is a celebrated upside to having driverless robotaxis provide all imagined passenger trips, it is unclear how to ensure transportation equity and access regardless of one's ability to pay or perambulate. A for-profit TNC is inclined to cherry-pick the easiest and most lucrative customer fares, leaving the rest to a declining travel experience and eventually to declining access.<sup>8</sup> Making all or most trips in commercial robotaxis possible from the social perspective would likely require a system of government-mandated incentives supporting a public policy of geographic, socio-economic, and environmental equity in mobility services.<sup>9</sup>

Some car companies plan to be both sellers of vehicles and sellers of rides. This trend is illustrated by the Daimler-Benz and BMW joint venture combining Car2Go and ReachNow short term car rental services, and both GM and Ford describing intent to develop future ride services.<sup>10</sup>

The ideal scenario for public transit planners would be to have an optimized, dense, and always-available transit network that is also affordable for the taxpayer. While the human-controlled vehicles of 2019 heavily bias ownership toward the personal household one, the impending no-human-driver vehicle expected to appear in the last three-quarters of this century may be able to change the balance.

## THE CASE FOR AUTOMATED TRANSIT

An important challenge to present operations is the starting point. Current fixed-route transit ridership would dramatically erode if personally owned automated vehicles to become as safe, convenient, and effective as promoted in speculative forecasts and if the total cost of vehicle ownership to become affordable after years of extensive innovation. Alternatively, if massive commercial robotic fleets optimized for effective rides-on-demand service were to materialize and provide rides to anywhere at the touch of a smart phone, as promised by some pundits, it is hard to see how today's public transit bus routes could survive. In other words, local bus service is under

threat from automated vehicles coming from both private and commercial AV markets. As reported by the PBS Nova blog,

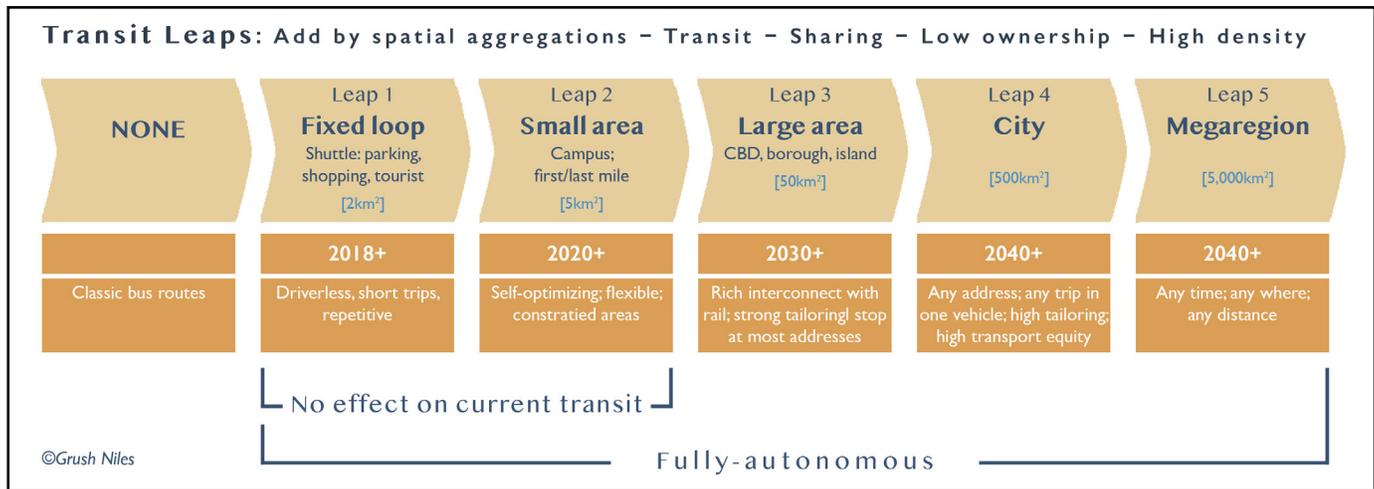
Boston Consulting Group found the cost of conveying one passenger by an autonomous vehicle would be 35% less than by conventional taxi at the average taxi occupancy rate of 1.2 passengers. Increase an autonomous vehicle's rate of occupancy to just two passengers and the cost per passenger becomes competitive with mass transit.<sup>11</sup>

Given the nature of the disruption expected to be caused by the Level 5 autonomous vehicles and the promise of cheap on-demand robotic fleets, the transit of 30 years ahead cannot possibly resemble the transit of today. It will not be dominated by large vehicles on fixed routes and rigid schedules, even if such options, especially the rail mode, will serve residual roles. Future transit cannot be focused only on commuters to and from work. It cannot be sustainable serving only a small fraction of total trips. In summary, public transportation must evolve dramatically or it will not persist. Importantly, how the future unfolds matters for transportation equity.

## TRANSIT LEAP

For all populations to access and enjoy AV advantages, transit agencies could play a leadership role starting immediately by tying automated vehicle adoption to the policy goal of realizing long-run transportation equity. However, adding automated driver assistance to buses is not going to change the trajectory of public transit, nor will making deals with Uber and Lyft to provide discounted rides to transit hubs. A bigger leap is needed, which here is called Transit Leap.

Transit Leap comprises an intentional growth of automated, road-based, people-moving applications (Figure 2). Beginning with constrained, short, repetitive, fixed shuttle routes, and moving through opportunistic stages of growth in route length, coverage area, schedule flexibility and app-based service levels, from small, slow, local demonstration services with a handful of early vehicles, Transit Leap could evolve over a period of a few years into massive swarms of on-demand vehicles and routes. This approach adds clusters of automated vehicles in one constrained area at a time, growing market adoption (and its social value) spatially rather than consumer-by-consumer. Transit Leap vehicles are fully autonomous (Level 5) from the outset, avoiding the uncertainty of wide-area infrastructure preparedness and the distracted driver problem noted by Google.<sup>12</sup>



**Figure 2. Transit Leap Levels are Described Spatially Rather than as Autonomy Levels**

*Note:* All Leap implementations require Level 5 autonomy, appropriate for their operating domain. The maturity of each Leap is enabled by then-current reliability of Level 5 vehicle operation. Diagram by Grush Niles Strategic.

Each stage would operate in accordance with evolving technology without necessarily causing transit job loss as employee position descriptions could evolve to cover new tasks in a revised system. Beginning with first-and-last mile applications that fill an immediate unaddressed need, Transit Leap could progress through larger and more capable roll-outs toward a long-run scenario of massive shared fleets that span urban regions after mid-century.

Transit Leaps 1 and 2 can commence immediately. The use of Level 5 automated minibuses to carry six to 12 passengers at slow speeds along carefully prepared routes has already been demonstrated in several countries. The CityMobil2 trials in the European Union are a prominent example,<sup>13</sup> and other Level 1 deployments are visible in California, Florida, Michigan, United Arab Emirates, Switzerland, and a dozen other locations worldwide.<sup>14</sup> Transit Leaps 2 through 5 could be rolled out over the ensuing decades in three additional overlapping stages. At this moment of publication, the technology is only ready for Leaps 1 and 2, but the existence of numerous successful Leaps 1 and 2 will soon engender a few cases of modest Leap 3. Nothing drives innovation like adoption and visible markets.

If a government transit agency wants to compete with consumer adoption of automated driver assistance, or even just understand the potential of AV technology, adoption of operational public transit applications at SAE Level 5 is the best route.

## CONCLUSION

Stimulated by a steady stream of news reports and corporate announcements, we can now imagine a future world in which a vehicle with no human in control can go anywhere a human-operated vehicle can go. There would be diminished utility in owning a vehicle. This is the ideal world of Transportation as a Service (TaaS).

The growth of robotic vehicle technology will not leave public transit undisturbed. Instead, robotics offers public transit the choice between increasing service levels and ridership per dollar, or being replaced by private TaaS operators that impinge on public transit. There are steps a public agency can take now to defend its relevance and existence.

Decades may pass before SAE Level 5 becomes capable of operating over wide areas that human drivers handle easily. In the interim, robotic technology will be able to operate with a high degree of reliability at Level 5 in constrained areas at urban street speeds, up to 30 miles per hour. Public transit agencies with a charter that supports innovation in service delivery and a board of directors willing to act could move forward on deploying these vehicles now.

Geographically constrained Level 5 vehicles (Transit Leaps 1 and 2) can at first complement existing fixed-route transit and then begin to disrupt it (Leaps 3 to 5), growing ridership, confidence, markets, and jobs. Those public transit agencies that deploy Transit Leap 3 applications within the next few years have the best chance to see a long-run significant increase in ridership supported by a meaningful reduction in household vehicle ownership. If some combination of public and private TaaS throughout a metropolitan region can eventually provide 24/7 rapid response (likely involving public-private financing partnerships collaboration with transportation networking companies), there is hope that the dominant consumer preference for automotive ownership could be tamped down, at least in dense cities.

For the long run, metro regions could make road congestion disappear by moving 80 percent of all vehicle trips, including public transit ones, into the shared vehicle sector, and letting 20 percent of vehicle trips remain in the household-owned vehicle sector. If the shared vehicles were to handle on average four times the vehicle miles traveled compared to the average household vehicle, urban regions could remove 40 percent of the vehicles on their roads from the business-as-usual case.<sup>15</sup> Remaining relevant to evolving mobility options and fully participating to achieve this level of environmental improvement makes it worthwhile for progressive agencies to take a Transit Leap.

*Specially prepared for Mineta Transportation Institute, this essay summarizes ideas contained in a book The End of Driving: Transportation Systems and Public Policy Planning for Autonomous Vehicles by Bern Grush and John Niles. Some of the perspective here was originally presented in an award-winning paper by Bern Grush and John Niles, "How cities can use autonomous vehicles to increase transit ridership and reduce household ownership," prepared for the Joint Conference of the Canadian Transportation Research Forum and the Transportation Research Forum, Toronto, Ontario, Canada, May 2016.*

## ENDNOTES

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### About the Author

John Niles researches, designs, plans, and evaluates transportation improvement policies and actions as an independent consultant. He is a Research Associate with the Mineta Transportation Institute at San Jose State University, leading teams that prepared reports on new planning processes for transit-oriented development, bus rapid transit incrementalism, and park-and-ride advantages for transit ridership. Lately he has been focused on priorities for automated vehicle deployment and new incentives for higher vehicle occupancy in peak periods to reduce congestion.

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