The Impact of Autonomous Vehicles on Urban Land Use Patterns

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ABSTRACT

Autonomous vehicles are coming. The only questions are how quickly they will arrive, how we will manage the years when they share the road with conventional vehicles, and how the legal system will address the issues they raise. This Article examines the impact the autonomous vehicle revolution will have on urban land use patterns.

Autonomous vehicles will transform the use of land and the law governing that valuable land. Automobiles will drop passengers off and then drive themselves to remote parking areas, reducing the need for downtown parking. These vehicles will create the need for substantial changes in roadway design. Driverless cars are more likely to be shared, and fleets may supplant individual ownership. At the same time, people may be willing to endure longer commutes, working while their car transports them.

These dramatic changes will require corresponding adaptations in real estate and land use law. Zoning laws, building codes, and homeowners' association rules will have to be updated to reflect shifting needs for parking. Longer commutes may create a need for stricter environmental controls. Moreover, jurisdictions will have to address these changes while operating under considerable uncertainty, as we all wait to see which technologies catch on, which fall by the wayside, and how quickly this revolution arrives. This Article examines the legal changes that are likely to be needed in the near future. It concludes by recommending that government bodies engage in scenario planning so they can act under conditions of ambiguity while reducing the risk of poor decisions.

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> "In 2018, we should imagine a visit from a person from the year 2100. Will she look on our choices admiringly, or with her head in her hands at the chaos we are about to create? That is the moment we face."[1]
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> - Samuel I. Schwartz

1. SAMUEL I. SCHWARTZ WITH KAREN KELLY, NO ONE AT THE WHEEL: DRIVERLESS CARS AND THE ROAD OF THE FUTURE 9 (2018). The author, known popularly as "Gridlock Sam," previously served as Traffic Commissioner for New York City and as Chief Engineer for the New York City Department of Transportation.

I. INTRODUCTION TO AUTONOMOUS VEHICLES: DEFINITIONS, BENEFITS, DRAWBACKS

Self-driving vehicles have featured in the American imagination at least since George Jetson launched Elroy to Little Dipper School, Judy to Orbit High School, and Jane to the Shopping Center in self-propelled pods.[2] The U.S. Department of Transportation (USDOT) portrayed fully autonomous vehicles (AVs) with substantially greater precision in 2018, defining "Full Automation" of a vehicle as "The full-time performance by an automated driving system of all aspects of the dynamic driving task under all roadway and environmental conditions that can be managed by a human driver."[3] USDOT and the Society of Automotive Engineers (SAE) have adopted a taxonomy that recognizes six different levels of automation, ranging from Level 0 (No Automation) to Level 5 (Full Automation).[4] Numerous vehicles on the road today offer Level 1 or Level 2 autonomy.[5] However you define the term, it seems evident that the market for AVs will flourish in the coming decades.[6]

A. Legal Issues, in General

Autonomous vehicles raise numerous legal issues, many of which have little to do with urban land use patterns. There are straightforward tort questions, such as who is liable when an AV is

2. Warnerarchive, *The Jetsons (Theme Song)*, YOUTUBE (Dec. 19, 2014), https://www.youtube.com/watch?v=tTq6Tofmo7E [https://perma.cc/5S6R-VQ77].

3. U.S. DEP'T OF TRANSP., AUTOMATED VEHICLES 3.0: PREPARING FOR THE FUTURE OF TRANSPORTATION vi (2018), https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/320711/preparing-future-transportation-automated-vehicle-30.pdf [https://perma.cc/2EYQ-Q796] [hereinafter USDOT, PREPARING FOR THE FUTURE]. Note that this definition was originally developed by the Society of Automotive Engineers. *Taxonomy and Definitions for Terms Related to Driving Automation Systems for On-Road Motor Vehicles J3016_201806*, SAE INT'L (June 15, 2018), https://www.sae.org/standards/content/j3016_201806/ [https://perma.cc/RRP2-QVXD]; *SAE International Releases Updated Visual Chart for Its "Levels of Driving Automation" Standard for Self-Driving Vehicles*, SAE INT'L (Dec. 11, 2018), https://www.sae.org/news/press-room/2018/12/sae-international-releases-updated-visual-chart-for-its-%E2%80%9Clevels-of-driving-automation%E2%80%9D-standard-for-self-driving-vehicles [https://perma.cc/3VM2-K5ZD] [hereinafter SAE INT'L, *Visual Chart*] (observing that USDOT's document "became a de facto global standard adopted by stakeholders in the automated vehicle technology").

4. USDOT, PREPARING FOR THE FUTURE, *supra* note 3, at viii; SAE INT'L, *Visual Chart*, *supra* note 3.

5. *See, e.g.*, Tom Voelk, *Our Cars Are Trying to Keep Us Safe. Here's How*, N.Y. TIMES: SMARTER LIVING (Aug. 8, 2019), https://www.nytimes.com/2019/08/08/smarter-living/our-cars-are-trying-to-keep-us-safe-heres-how.html [https://perma.cc/T6U7-T4LG] (noting that "the pace of autonomy is picking up to the point that Levels One and Two have become ubiquitous; beyond that, not so much," and providing numerous illustrations).

6. "I believe there is a really big business in autonomous vehicles. I wouldn't be going after it if I didn't think that." Brent Snavely, *Ford CEO Jim Hackett Shares what Matters to Him*, DETROIT FREE-PRESS (June 17, 2017, 11:11 PM), https://www.freep.com/story/money/cars/ford/2017/06/18/ford-ceo-jim-hackett/402178001/ [https://perma.cc/H8VA-V9LK] (quoting new Ford CEO Jim Hackett).

involved in a collision. Since there is no traditional driver operating a fully autonomous vehicle, the manufacturer of the vehicle, the hardware manufacturer, the software developer, one or more public or private utilities that installed and maintain data devices, or the municipality that established vehicle standards all may face greater liability than in the past.[7] Software developers make mistakes, and there will inevitably be an AV software glitch analogous to that found recently in Boeing 737 Max 8 airliners.[8] Tort law will need to adapt to these changes more broadly, as vehicles most likely become safer overall despite inevitable setbacks.[9] Insurance law will need to co-evolve with tort law.[10]

Software developers will have to make difficult elections about how to respond when a collision is inevitable.[11] This means they will face

7. AVs may prompt consumer opposition when they harm someone, even though traditional vehicles are more dangerous overall. *See, e.g.*, Steven Overly, *The Big Moral Dilemma Facing Self-Driving Cars*, WASH. POST (Feb. 20, 2017, 9:00 AM), https://www.washingtonpost.com/news/innovations/wp/2017/02/20/the-big-moral-dilemma-facing-self-driving-cars [https://perma.cc/4TM8-MMYU] (paraphrasing MIT Professor Iyad Rahwan by noting, "While we may assign blame or seek retribution—by sending a drunk driver to prison, for example—the capacity for human failure is not hard to understand or empathize with. The same is not true for machines," and deeming this phenomenon "algorithm aversion").

8. *See, e.g.*, Chris Isidore, *Boeing's Latest 737 Max Problems Could Come at Huge Cost*, CNN (Oct. 18, 2019, 7:01 PM), https://www.cnn.com/2019/10/18/business/boeing-737-max-financial-impact/index.html [https://perma.cc/W8MR-GEW2] ("The plane was grounded in March after an onboard automatic safety feature was tied to two fatal crashes that killed 346 people.").

9. *See* NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., FEDERAL AUTOMATED VEHICLES POLICY: ACCELERATING THE NEXT REVOLUTION IN ROADWAY SAFETY 46 (2016), https://www.transportation.gov/sites/dot.gov/files/docs/AV%20policy%20guidance%20PDF.pdf [https://perma.cc/JPV8-L5Z4] [hereinafter NHTSA, ACCELERATING] ("Rules and laws allocating tort liability could have a significant effect on both consumer acceptance of HAVs [highly automated vehicles] and their rate of deployment. Such rules also could have a substantial effect on the level and incidence of automobile liability insurance costs in jurisdictions in which HAVs operate."); *see also* Kenneth S. Abraham & Robert L. Rabin, *Automated Vehicles and Manufacturer Responsibility for Accidents: A New Legal Regime for a New Era*, 105 VA. L. REV. 127, 145-69 (2019) (proposing an alternative insurance model that depends on whether one or both of the vehicles involved in a collision are autonomous); Kevin Reagan, *Whose Insurance Pays in a Driverless Vehicle Crash?*, GOVERNING (Nov. 23, 2019), https://www.governing.com/news/headlines/Whose-Insurance-Pays-in-a-Driverless-Vehicle-Crash.html [https://perma.cc/2T7H-TKCB] ("If humans no longer control their vehicles, the courts will have to decide whether they can still be held liable for accidents and property damage. Some experts have suggested judges think of self-driving cars as analogous to elevators, autopilot systems—or horse-drawn carriages.").

10. *See, e.g.*, GARY SILBERG ET AL., KPMG, PROTECTING THE FLEET . . . AND THE CAR BUSINESS 12 (2017), https://advisory.kpmg.us/content/dam/advisory/en/pdfs/protecting-the-fleet-web1.pdf [https://perma.cc/Q82H-BTXE] ("Car insurers will need to innovate new methods of pricing policies and determining coverage(s) aligned to the changing risk landscape, in which roads are safer and therefore both policy sales and premium rates are likely to drop off."). *But see* Bryant Walker Smith, *Automated Driving and Product Liability*, 2017 MICH. ST. L. REV. 1, 2 ("[T]he current product liability regime, while imperfect, is probably compatible with the adoption of automated driving systems.").

11. There is ongoing debate as to whether fatal collisions are inevitable, with some experts arguing that proper design of roadways and vehicles can sharply reduce highway

more variations of the trolley problem than even the finest first-year Torts professor could possibly imagine.[12] Autonomous vehicles are sure to face greater public resistance if prospective buyers know that the software is programmed to sacrifice the driver to protect several pedestrians, a decision that likely diverges from the one an active driver would make for herself.[13] Indeed, there is some indication that people from different cultures show worrisomely different preferences over who should be spared when a collision is inevitable.[14] This raises

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fatalities and injuries, perhaps to zero. *See, e.g.*, *Vision and Mission of the Office of Safety: ZERO DEATHS,* FED. HIGHWAY ADMIN.: SAFETY, https://safety.fhwa.dot.gov/about/ [https://perma.cc/6DU2-4893] (last modified Jan. 23, 2018) ("Together with our customers, stakeholders, partners, and other US Department of Transportation (USDOT) agencies, the Office of Safety is committed to the vision of zero deaths and serious injuries on the Nation's roadways."); *What is Vision Zero?*, VISION ZERO NETWORK, https://visionzeronetwork.org/about/what-is-vision-zero/ [https://perma.cc/6YDR-RYSN] (last visited Dec. 28, 2020) ("Vision Zero is a strategy to eliminate all traffic fatalities and severe injuries, while increasing safe, healthy, equitable mobility for all."). Oslo, Norway has had considerable success with this effort. *See, e.g.*, Katie Pyzyk, *Oslo Closing in on Vision Zero Goal with No Pedestrian or Cyclist Deaths in 2019*, SMARTCITIESDIVE, (Jan. 7, 2020), https://www.smartcitiesdive.com/news/oslo-vision-zero-pedestrian-cyclist-deaths-2019/569878/ [https://perma.cc/8C58-HMPW] ("Oslo, Norway is getting closer to achieving a Vision Zero goal, with zero pedestrian or cyclist deaths last year. The city's lone traffic death occurred when a driver ran his car into a fence this summer—a decline from five traffic fatalities in 2018 . . . .").

12. NHTSA, ACCELERATING, *supra* note 9, at 26 ("Even in instances in which no explicit ethical rule or preference is intended, the programming of an HAV [highly automated vehicle] may establish an implicit or inherent decision rule with significant ethical consequences."); *see also* Heather M. Roff, *The Folly of Trolleys: Ethical Challenges and Autonomous Vehicles*, BROOKINGS (Dec. 17, 2018), https://www.brookings.edu/research/the-folly-of-trolleys-ethical-challenges-and-autonomous-vehicles/ [https://perma.cc/C8CV-RJCB] (arguing that other analogies apply more precisely to the ethical issues autonomous vehicles raise and noting, "It is not whether a car ought to kill one to save five, but how the introduction of the technology will shape and change the rights, lives, and benefits of all those around it").

13. Jean-Francois Bonnefon et al., *The Social Dilemma of Autonomous Vehicles*, 352 SCI. 1573, 1574 (2016) ("[R]espondents indicated a significantly lower likelihood . . . of buying the AV when they imagined the situation in which they and their family member would be sacrificed for the greater good. In other words, even though participants . . . agreed that utilitarian AVs were the most moral, they preferred the self-protective model for themselves."); *id.* at 1575 ("[P]eople praise utilitarian, self-sacrificing AVs and welcome them on the road, without actually wanting to buy one for themselves."). Of course, that same vehicle owner might just as easily be saved when someone else's vehicle makes a similar decision to sacrifice its own driver. *See* Samantha Godwin, *Ethics and Public Health of Driverless Vehicle Collision Programming*, 86 TENN. L. REV. 135, 173 (2018) ("The incentive-weighted system rewards transportation choices that reduce danger in the aggregate by prescribing collision programming that prioritizes their safety relative to those adopting less aggregate safety-promoting choices.").

14. In a recent study, more than 39 million users from 233 countries played a version of the trolley game. Edmond Awad et al., *The Moral Machine Experiment*, 563 NATURE 59, 59 (2018), https://www.nature.com/articles/s41586-018-0637-6 [https://perma.cc/G6DA-VKWR]. The strongest preferences shown were for saving humans over animals, sparing more lives rather than fewer, and sparing young lives. *Id.* at 60. Users showed weaker preferences for "women over men, athletes over overweight persons, [and] executives over homeless persons." *Id.* People (other than criminals) were favored over pets, but dogs were favored over criminals, which were in turn favored over cats. *Id.* at 61. Central and South

the question of whether vehicles would need to be programmed differently in different nations.[15] More generally, the necessity for such software raises the question of whether AVs can be programmed to make more beneficial and equitable decisions than human drivers collectively make today.

There have been objections to AV manufacturers beta testing new vehicles on populations that have not consented.[16] AV software, along with the complex new hardware that runs it, also raises a variety of intellectual property issues.[17] In addition, AVs will retain enormous amounts of data for purposes of incident reconstruction and future software upgrades.[18] Maintenance of this information introduces significant privacy issues.[19]

B. Benefits

Widespread deployment of AVs will generate abundant benefits. When vehicle software improves to the point that AVs are safer than human drivers, as seems likely, there will be a reduction in death,

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American nations were more likely to spare younger characters than East and South Asian nations and showed a higher preference for sparing women and physically fit characters. *Id.*

15. For obvious historical reasons, a German government commission has recommended that distinctions based on age, gender, or physical or mental constitution may not be considered. Caroline Lester, *A Study on Driverless-Car Ethics Offers a Troubling Look into our Values*, NEW YORKER (Jan. 24, 2019), https://www.newyorker.com/science/elements/a-study-on-driverless-car-ethics-offers-a-troubling-look-into-our-values [https://perma.cc/2GDE-YYYV]. "Volkswagen sells more automobiles than any other company in the world. But that manufacturing power comes with a complicated moral responsibility. What should a company do if another country wants its vehicles to reflect different moral calculations?" *Id.* But the German commission's head "worries about letting autocratic governments tinker with the code. He imagines a future in which China wants the cars to favor people who rank higher in its new social-credit system, which scores citizens based on their civic behavior." *Id.*

16. *See, e.g.*, Simon Romero, *Wielding Rocks and Knives, Arizonans Attack Self Driving Cars*, N.Y. TIMES (Dec. 31, 2018), https://www.nytimes.com/2018/12/31/us/waymo-self-driving-cars-arizona-attacks.html [https://perma.cc/U9EH-WPDQ] (describing vandalized vehicles and threats to test drivers).

17. Jim Motavalli, *Locking More Than the Doors as Cars Become Computers on Wheels*, N.Y. TIMES (Mar. 7, 2019), https://www.nytimes.com/2019/03/07/business/car-hacks-cybersecurity-safety.html [https://perma.cc/QPB5-JJLG] ("The average car [today] has over 150 million lines of computer code, and some have even more than a Boeing 787.").

18. NHTSA, ACCELERATING, *supra* note 9, at 17 ("Manufacturers and other entities should have a documented process for testing, validation, and collection of event, incident, and crash data, for the purposes of recording the occurrence of malfunctions, degradations, or failures in a way that can be used to establish the cause of any such issues."); NAT'L ASS'N CITY TRANSP. OFFICIALS, BLUEPRINT FOR AUTONOMOUS URBANISM 70-77 (2d ed. 2019), https://nacto.org/publication/bau2/ [https://perma.cc/RHL3-RQ2M] [hereinafter NACTO, BLUEPRINT] (describing the different types of data and the best ways to use and safeguard this information).

19. *See, e.g.*, NHTSA: ACCELERATING, *supra* note 9, at 19-20 (establishing privacy standards); *see also* Maurice Stucke & Ariel Ezrachi, *Alexa et al., What Are You Doing With My Data?*, 5 CRITICAL ANALYSIS L. 148, 161-65 (2018) (discussing privacy concerns). *See generally* Sylvia Zhang, *Who Owns the Data Generated by your Smart Car?*, 32 HARV. J.L. & TECH. 299 (2018) (discussing several alternative data-ownership models).

personal injury, and property damage caused by motor-vehicle collisions.[20] Land currently devoted to surface parking lots and elevated parking structures will be freed up for other uses, as vehicles will be able to drive themselves to remote storage locations on less valuable real estate rather than spending the day within walking distance of their owners.[21] In the alternative, these vehicles may be owned as fleets, effectively operating as Ubers without drivers. This means they may rarely park at all, moving instead to their next occupant's pickup location and reducing the overall number of vehicles on the road. Under either model, urban planners will be able to repurpose much of the precious downtown land that is now dedicated to the storage of empty vehicles.[22]

Vehicle occupants will no longer have to concentrate on driving, which will transform every autonomous vehicle into a roving office, family room, or even bedroom.[23] This transition will free up hundreds of millions of hours, as workers use their commuting time for purposes other than staring at the road, including work.[24] Commuting times are

20. NIDHI KALRA & DAVID G. GROVES, THE ENEMY OF GOOD: ESTIMATING THE COST OF WAITING FOR NEARLY PERFECT AUTOMATED VEHICLES 1 (2017), https://www.rand.org/pubs/research_reports/RR2150.html [https://perma.cc/PH5V-RXH2] (noting that AVs "are never drunk, distracted, or tired," do not have blind spots, make better decisions, and execute better). 36,560 people were killed in motor-vehicle traffic crashes on American roadways in 2018. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., DOT HS 812 826, TRAFFIC SAFETY FACTS - 2018 FATAL MOTOR VEHICLE CRASHES: OVERVIEW (2019), https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812826 [https://perma.cc/LQD9-LCDK].

21. *See* Joe Pobiner, *Autonomous Vehicles Part II: What Lies Ahead*, GENSLERONCITIES (May 25, 2017), http://www.gensleron.com/cities/2017/5/25/autonomous-vehicles-part-ii-what-lies-ahead.html [https://perma.cc/NVF2-2DRV] ("A frequently estimated number of US parking spaces is between 800 and 900 million. That's around 10,500 square miles of parking (both surface lots and parking structures)—about the size of the state of Massachusetts!"). *See generally* DONALD C. SHOUP, THE HIGH COST OF FREE PARKING 205-07 (2005) (noting one expert's estimate that the total cost of off-street parking in the U.S. may be as high as $226 billion in 1991 dollars, equivalent to as much as 3.7 percent of the nation's total economic output, and that as little as 1% of that cost is paid directly by drivers).

22. *See* Laura Bliss, *Parking is Sexy Now. Thank Donald Shoup.*, BLOOMBERG (May 30, 2018, 11:52 AM), https://www.bloomberg.com/news/articles/2018-05-30/parking-policy-is-hot-thanks-to-donald-shoup [https://perma.cc/J68G-XJQ5] (interview with parking expert Donald Shoup) (quoting Shoup as saying, "a lot of [Uber's and Lyft's] traffic goes to places where parking is expensive. That is one reason that people use their services. They understand that requirements that build in too much parking are their enemy.").

23. One should not underestimate the risk of one's car becoming their roving office. *See* Rahawa Haile, *Full Tilt: When 100% of Cars Are Autonomous–The Seizure of Commuting Time*, N.Y. TIMES MAG. (Nov. 8, 2017), https://www.nytimes.com/interactive/2017/11/08/magazine/tech-design-autonomous-future-cars-100-percent-augmented-reality-policing.html?emc=eta1 [https://perma.cc/7D8S-2DU4] ("[T]he way we currently fill our downtime leads me to believe that some form of digital immersion will take precedence, as bosses expect employees to work on their way to and from work.").

24. The coronavirus pandemic has highlighted to many workers just how much time is saved when one can work from home, without losing time to commuting. The use of autonomous vehicles does not eliminate a worker's commute, but it does transform it into productive time.

likely to change as a result of the deployment of AVs. A trip of the same distance should take less time, as vehicles are able to communicate seamlessly with one another. Instead of making eye contact at a four-way stop sign and waiting one's turn, vehicles will reach instantaneous consensus as to the order of passage, perhaps choosing the sequence that best reduces cumulative wait time.[25] Navigation systems will select intelligent routes with complete knowledge of the routes that other vehicles have selected, a process that is already underway with traditional vehicles.[26] Collisions and the traffic jams that result should be sharply reduced. Balanced against these speed enhancements is the fact that workers may be willing to live further from their jobs and endure longer drives if travel distance can be covered more quickly and the time can be used more profitably.[27]

Freedom of movement will be enhanced for several large and important populations, most notably children, senior citizens, and those with mobility impairments, all of whom today must (or, perhaps, should) rely on others to drive them.[28] The widespread use of AVs is potentially greener, as well.[29] To begin with, many AVs are likely to be electric, although electric vehicles will probably replace vehicles powered by fossil fuels even if they are not autonomous.[30] More

25. Clive Thompson, *Full Tilt: When 100% of Cars Are Autonomous–Cities Without Signs*, N.Y. TIMES MAG. (Nov. 8, 2017), https://www.nytimes.com/interactive/2017/11/08/magazine/tech-design-autonomous-future-cars-100-percent-augmented-reality-policing.html?emc=eta1 [https://perma.cc/5GDF-S7W6] [hereinafter Thompson, *Full Tilt*] (noting how automated "intersection managers" can help speed traffic through busy intersections); *infra* note 128 (discussing slot-based intersections).

26. Radim Cmar, *How Intelligent Car Navigation Could Improve City Traffic Conditions*, SMARTCITIESWORLD (May 13, 2019), https://www.smartcitiesworld.net/opinions/opinions/how-intelligent-car-navigation-will-improve-city-traffic-conditions [https://perma.cc/H7BV-LQT2] ("Connected cars now present opportunities to develop car navigation further, and they could lead to fewer traffic jams in major cities.").

27. *See* Sarah J. Fox, *Planning for Density in a Driverless World*, 9 NE. U. L.J. 151, 167-68 (2017) (describing the relationship between vehicle ownership and urban sprawl).

28. Undocumented immigrants who are not eligible to acquire a driver's license in some states and formerly incarcerated individuals who lack adequate identification documents to obtain a driver's license may also benefit. Frank Douma et al., *The Legal Obligations, Obstacles, and Opportunities for Automated and Connected Vehicles to Improve Mobility and Access for People Unable to Drive*, 2017 MICH. ST. L. REV. 75, 82-85 (2017).

29. Myriam Alexander-Kearns, Miranda Peterson & Alison Cassady, *The Impact of Vehicle Automation on Carbon Emissions: Where Uncertainty Lies*, CTR. FOR AM. PROGRESS (Nov. 18, 2016, 6:30 AM), https://www.americanprogress.org/issues/green/reports/2016/11/18/292588/the-impact-of-vehicle-automation-on-carbon-emissions-where-uncertainty-lies/ [https://perma.cc/288P-XZU4] ("Whether AVs mitigate or worsen carbon pollution from light-duty vehicles in the transportation sector will depend on three key factors: their effect on the total vehicle-miles traveled in the United States; their impacts on congestion; and their fuel efficiency and fossil fuel consumption.").

30. *Id.* (noting that "concerns about fuel consumption are moot if autonomous vehicles on the road are electric vehicles" and suggesting that the expanded use of AVs might encourage the use of electric vehicles by reducing owner concern about the availability of recharging stations).

importantly, coordination of travel by software is likely to be more efficient, as vehicles are able to decide quickly on the most efficient route to a destination and to adapt to changes in traffic patterns as their trip progresses.[31] Autonomous vehicles will not accelerate rapidly and then jam on their brakes.[32] Vehicles will spend less time at choke points such as traffic lights, stop signs, and highway merges.[33] Municipalities will thus be able to make more efficient use of their roadways, allowing them to free up some current roadway space for other uses. This benefit, too, may be offset by longer commutes that result as workers become more willing to live far from their workplaces.

C. Drawbacks

Increased use of AVs will also create new problems and exacerbate existing ones. If workers are willing to commute greater distances, cities may face increased sprawl, necessitating construction of new infrastructure in far-flung exurbs. Although driving will have become more efficient, there may turn out to be more of it, offsetting some or all of the green benefits of the autonomous vehicle revolution.

The period of transition to self-driving vehicles may be quick.[34] More likely, though, it will last decades, given the lengthy useful life of the many reliable Level 0 and Level 1 cars and trucks currently on the road.[35] Some analysts are fairly pessimistic on this point, believing

31. Cmar, *supra* note 26.

32. Alexander-Kearns, Peterson & Cassady, *supra* note 29 ("AV technology could help to avoid inefficient driving conditions, such as abrupt stops and starts common in heavy traffic. Even at higher speeds on highways, dramatic braking and other human reactions can cause congestion. Without these reactions, cars could travel close together safely.").

33. *Id.* (quoting one researcher as predicting "you will never get in a traffic jam. . . . If all vehicles are coordinated, they will never have to come to a full stop or a red light.").

34. For a stunning pair of photographs illustrating the rapid transition from horse-drawn carriages to motor vehicles in Manhattan, see Joe Weisenthal, *5th Avenue: 1900 Vs. 1913*, BUS. INSIDER (Mar. 31, 2011), https://www.businessinsider.com/5th-ave-1900-vs-1913-2011-3?utm_source=email&utm_medium=referral&utm_content=topbar&utm_term=desktop&pt=385758&ct=Sailthru_BI_Newsletters&mt=8&utm_campaign=email_article [https://perma.cc/FA97-6PHF].

35. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., AUTOMATED DRIVING SYSTEMS 2.0: A VISION FOR SAFETY 12 (2017), https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf [https://perma.cc/9T4V-SYXW] ("Given that a mix of vehicles with ADSs [Automated Driving Systems] and those without will be operating on public roadways for an extended period of time, entities still need to consider the possible scenario of another vehicle crashing into an ADS-equipped vehicle and how to best protect vehicle occupants in that situation."); *see also* Danielle Szatkowski, *Average Age of Vehicles on U.S. Roads Hits 11.8 Years*, AUTO NEWS (June 27, 2019 7:00 am), https://www.autonews.com/automakers-suppliers/average-age-vehicles-us-roads-hits-118-years [https://perma.cc/UEA2-SA3K].

the changeover will take at least that long.[36] Other observers believe that consumers will switch to autonomous vehicles as soon as they see their neighbors making this change.[37] Whatever happens, conventional and autonomous vehicles will share the same roads for twenty years or more.[38] During this time, AVs will have to be able to anticipate the actions of vehicles driven by less predictable human drivers, and those humans still driving will have to learn to interact with vehicles conducted by drivers with whom they cannot simply make eye contact.[39] These later-adopting human drivers may quickly figure out how to take advantage of their autonomous counterparts, getting a jump on them by knowing their habits. At some point, human drivers may be banned from certain roads, and some of them may not leave without a fight.[40]

This transition will also lead to dramatic changes in the workforce.[41] Driving jobs may disappear entirely, displacing 3.5 million truck drivers[42] and another 370,400 taxi drivers, ride-hailing

36. *See, e.g.,* TODD LITMAN, AUTONOMOUS VEHICLE IMPLEMENTATION PREDICTIONS: IMPLICATIONS FOR TRANSPORT PLANNING 3 (2020), vtpi.org/avip.pdf ("[T]here are good reasons to be skeptical. Most optimistic predictions are made by people with financial interests in the industry, based on experience with disruptive technologies such as digital cameras, smart phones and personal computers. They tend to ignore significant obstacles to autonomous vehicle development, and exaggerate future benefits."); *id.* at 34 (providing a projected timeline).

37. *See, e.g.*, Tracy Hresko Pearl, *Hands Off the Wheel: The Role of Law in the Coming Extinction of Human-Driven Vehicles*, 33 HARV. J.L. & TECH. 427, 470-71 (2020) (illustrating the significance of social pressure in purchasing decisions).

38. LITMAN, *supra* note 36, at 55 ("[I]t will probably be 2045 before half of new vehicles are autonomous, 2060 before half of the vehicle fleet is autonomous, and possibly longer due to technical challenges or consumer preferences.").

39. *See* Abraham & Rabin, *supra* note 9, at 129-32 (summarizing the possible impact on tort law of having a mix of autonomous and conventional vehicles sharing the road).

40. *See, e.g.*, SCHWARTZ, *supra* note 1, at 62 (noting that horses are not permitted on interstate highways); M.R. O'Connor, *The Fight for the Right to Drive*, NEW YORKER (Apr. 30, 2019), https://www.newyorker.com/culture/annals-of-inquiry/the-fight-for-the-right-to-drive?utm_campaign=aud-dev&utm_source=nl&utm_brand=tny&utm_mailing=TNY_Daily_043019&utm_medium=email&bxid=5be9e0f724c17c6adf60075b&user_id=23068745&esrc=&utm_term=TNY_Daily [https://perma.cc/Q5B7-JY4V] (describing "the Human Driving Association, an organization aiming to protect people's freedom of movement and right to drive their own cars" and noting that its founder's manifesto "begins with a picture of a steering wheel and the words 'From my cold, dead hands'"). *But see* Pearl, *supra* note 37, at 472 ("[B]y the point at which that issue becomes relevant, consumer preference may have fixed the problem. . . . After all, no jurisdiction seems to have banned outright the use of horses on public roads in the early decades of the twentieth century, and yet, by the middle of that century, horses had been virtually eliminated from U.S. roads.").

41. *See* William F. Fox, *The Influence of Autonomous Vehicles on State Tax Revenue*, PEW TRUSTS 13 (Nov. 12, 2019), https://www.pewtrusts.org/en/research-and-analysis/white-papers/2019/12/how-autonomous-vehicles-may-impact-state-revenue [https://perma.cc/JD9M-62RN] [hereinafter Fox, *Influence*] (estimating that one-sixth of the US workforce holds jobs that involve manufacturing, using, or supporting the use of motor vehicles).

42. *See Economics & Industry Data*, AM. TRUCKING ASS'N, https://www.trucking.org/economics-and-industry-data [https://perma.cc/JV4B-9LV5].

drivers, and chauffeurs.[43] Jobs repairing vehicles are likely to drop.[44] New jobs—likely requiring technical expertise that the typical Uber driver or truck driver does not presently possess—will arise in the AV industry in fields such as manufacturing, programming, and equipment installation.[45]

State and municipal finances will have to survive a similar shake-up. Certain sources of revenue, such as parking fees, towing charges, fines for traffic violations, and gasoline tax revenues will dry up.[46] Airports have already suffered steep drops in parking revenue as ride-hailing services become more popular.[47] To the extent that airports use fees received from those who park vehicles to retire debt incurred to pay for parking structures, an unanticipated drop in airport parking could be financially devastating.[48] Other funding sources will increase or be newly developed.[49] Many heavily urbanized

43. *Taxi Drivers, Ride-Hailing Drivers, and Chauffeurs,* U.S. BUREAU OF LAB. STAT., https://www.bls.gov/ooh/transportation-and-material-moving/taxi-drivers-and-chauffeurs.htm [https://perma.cc/7ASD-LBGA] (last modified Sept. 4, 2019) (2018 figures; numbers include part-time workers).

44. *See* Voelk, *supra* note 5 ("A Honda executive told me it supplied far fewer replacement front fascias for modern CR-Vs equipped with automatic braking. And Subaru said last year that likely pedestrian-related insurance claims fell by 41 percent in vehicles with the second-generation EyeSight system . . . .").

45. These to-be-displaced workers are awakening to the upheaval they soon will face. *See, e.g.,* Romero, *supra* note 16 (quoting one expert who noted, "Just think about the [test drivers] inside these vehicles, who are essentially training the artificial intelligence that will replace them.").

46. Fox, *Influence*, *supra* note 41, at 43 ("Simulations for six states estimate that revenue reductions could range between 2.0 and 9.2 percent of total revenue and 60 percent or more of transportation revenue once AVs are fully adopted."); *id.* at 5 ("Each feature of AVs—electric, shared, and driverless—causes revenue losses given the tax structures that states have developed."); *see also* Kil Huh, *States and the Fiscal Constraints Autonomous Vehicles May Bring*, GOVERNING (Feb. 20, 2020), https://www.governing.com/finance/States-and-Fiscal-Constraints-Autonomous-Vehicles-May-Bring.html [https://perma.cc/N755-GU23] ("States currently collect about 8 percent of their total revenues from vehicle-related taxes and fees on sales, licensing, registration, and fuel—a key source of funding for infrastructure maintenance and improvements. They also collectively receive billions more from a wide range of related economic activity, including car rentals, auto repairs, vehicle financing, parking, ride-sharing and gas stations.")

47. Amy Zipkin, *Airports Are Losing Money as Ride-Hailing Services Grow*, N.Y. TIMES (Dec. 11, 2017), https://www.nytimes.com/2017/12/11/business/airports-ride-hailing-services.html [https://perma.cc/B5RR-RYLC] ("[Current] trend lines are hurting airports, which depend on fees from parking lots, rental car companies and taxis as their biggest source of revenue other than the fees paid by the airlines.").

48. *See, e.g.*, *Fitch Affirms Philadelphia Parking Auth (PA) Airport Parking Rev Bonds at 'A-'; Outlook Stable*, FITCH RATINGS (Oct. 31, 2019, 1:06 PM), https://www.fitchratings.com/research/infrastructure-project-finance/fitch-affirms-philadelphia-parking-auth-pa-airport-parking-rev-bonds-at-a-outlook-stable-31-10-2019 [https://perma.cc/B9AJ-T8Y8] (observing that "While the airport collects a fee from TNCs [transportation network companies such as Uber and Lyft] for each drop-off and pickup, none of the TNC revenue is shared with the authority to support the parking revenue bonds," and noting that the airport has made up for this lost revenue by increasing parking rates).

49. *See* Fox, *Influence*, *supra* note 41, at 5 ("Options for reforming direct taxes on mobility include expanding the sales tax to all forms of mobility (at the general sales tax rate

areas may join New York City in adopting congestion pricing.[50] Some cities have already begun charging vehicles a stopping fee that allows them to pick up or discharge passengers.[51] If reductions in downtown parking trigger an increase in commercial and residential construction on former parking sites, property tax revenues should increase.[52]

In summary, the United States is in the early stages of a transition that will revolutionize ground transportation. While this shift will likely take several decades to complete, the world of transit in thirty or forty years will differ dramatically and permanently from that of today. Just as smartphones have caused enormous changes in telecommunications, the media, and privacy norms, the more gradual conversion to an all-AV fleet will solve some current problems and create a raft of new ones, some of which are easier to foresee than others.

The remainder of this Article will focus on a small slice of these benefits and drawbacks, namely those affecting urban land use.[53] It then will propose various approaches jurisdictions can take to manage these changes.[54] Part II identifies and discusses the land use issues

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or a selected rate), levying VMT [vehicle miles traveled] taxes, and imposing congestion charges. These options are not mutually exclusive . . . .").

50. Central Business District Tolling Program, S. 1509-C, 2019 Leg. (N.Y. 2019) https://nyassembly.gov/leg/?default_fld=&leg_video=&bn=A02009&term=2019&Summary=Y&Actions=Y&Text=Y [https://perma.cc/FVF5-C9SH]. *But see* Clayton Guse, *NYC Congestion Pricing Program on Hold Due to Coronavirus, Imperiling MTA Modernization Plans*, N.Y. DAILY NEWS (Apr. 22, 2020), https://www.nydailynews.com/coronavirus/ny-coronavirus-congestion-pricing-on-hold-20200422-idyclofw4nbnnbc3ftbhjpjfpm-story.html (describing delays in obtaining necessary federal approval). This approach has been successful in other major cities, such as London, Stockholm, Singapore, and Milan. NACTO, BLUEPRINT, *supra* note 18, at 62 (describing the international history of "cordon pricing" and its beneficial effects).

51. Boston, for instance, already charges such fees at Logan Airport. *See, e.g.*, Christopher Gavin, *Here's What to Know about the Uber and Lyft Changes at Logan Airport*, BOSTON.COM (Apr. 25, 2019), https://www.boston.com/news/travel/2019/04/25/uber-lyft-changes-logan-airport [https://perma.cc/3MA6-TCBQ] (noting the adoption of a $3.25 drop-off fee in addition to the existing $3.25 pickup fee, with reductions for shared rides).

52. *See* BENJAMIN Y. CLARK ET AL., THE IMPACT OF AUTONOMOUS VEHICLES AND E-COMMERCE ON LOCAL GOVERNMENT BUDGETING AND FINANCE 6 (2017), https://scholarsbank.uoregon.edu/xmlui/bitstream/handle/1794/23329/UrbanismNext_ResearchBrief_001.pdf;jsessionid=A47DE008F8ED84BAAEFC424C179E4227?sequence=1 [https://perma.cc/8SPC-DKRC] (describing this phenomenon and noting that it might be temporarily offset due to a sudden oversupply of center-city construction sites); *id.* at 8 (predicting a similar outcome for business taxes).

53. Rural land uses raise unique and fascinating questions of their own, but this Article will focus on urban land use issues. Note that it seems likely that the major impact of AVs will be in urban areas, particularly as they first become prevalent. *See, e.g.*, BLOOMBERG PHILANTHROPIES & ASPEN INST. TAMING THE AUTONOMOUS VEHICLE: A PRIMER FOR CITIES 35 (2017), https://www.bbhub.io/dotorg/sites/2/2017/05/TamingtheAutonomousVehicleSpreadsPDF.pdf [https://perma.cc/4QNJ-HVY6] ("[U]rban markets will be the driving factor in how fast AV technology spreads.").

54. *See* Gregory H. Shill, *Should Law Subsidize Driving?*, 95 N.Y.U. L. REV. 498, 536 (2020) (discussing "the role of land use law in scripting everyday transportation choices, and

that will arise as autonomous vehicles become more prevalent. Some of these concerns will seem obvious, while other second-order problems may be harder to foresee. Part III will enumerate and describe some of the many ways that government entities might respond to these issues. Certain changes that are on the horizon may require prompt action, while others can wait until policymakers appreciate how new technologies are developing and how prevalent autonomous vehicles are becoming. Part IV will ask, more normatively, what governments should do, given the tremendous uncertainty they face and the potentially enormous costs of poor decisions. That Part will conclude by recommending that governments consider employing scenario planning as they proceed. Use of this forward-looking approach will allow government bodies to weigh various possible responses, evaluate the likelihood that each of these responses will achieve its goals, and assess the costs of reversing course if necessary.

II. LAND USE ISSUES AUTONOMOUS VEHICLES WILL RAISE

As Part I has suggested, the widespread deployment of autonomous vehicles will present a staggering range of legal issues that state and local government are only beginning to contemplate. Many of these open questions extend well beyond the scope of property and land use law. This Article focuses on the implications of AVs for urban land use patterns.

Part II of the Article will divide these land use issues into two categories. First, it will examine some of the more obvious issues that the increasing use of AVs likely will raise. These are concerns that every talented local government official is probably thinking about already. Second, it will discuss some of the less obvious issues. This second category includes numerous potential problems that may not occur immediately to local government officials, particularly those who have not yet focused on the huge impact AVs will have. There are also the "unknown unknowns": problems the AV revolution will create that no one has yet contemplated and that will not manifest themselves until the revolution is further along. Smartphones, for example, have made us less interactive on a personal level as users spend more and more time staring at their screens, and texting has largely supplanted telephone calls. Who knows what similarly unanticipated transformations autonomous vehicles will bring about?

thus in determining the liberty people enjoy—harming especially the level of personal freedom in cities that developed before World War II, where the built environment was not designed for and does not intrinsically require automobility").

A. Obvious Land Use Issues

1. Parking

Autonomous vehicles will have a significant impact on parking, particularly in crowded urban areas. The bulk of workforce transit today is by private motor vehicle, most commonly occupied solely by the driver of that vehicle.[55] Those vehicles, once empty, must be stowed nearby, usually for eight or more hours at a time. Shoppers, tourists, and other visitors to downtown areas often arrive by car and similarly must park their vehicles within a short walking distance of their destinations.

Autonomous vehicles need not spend the day near their occupants, since they can drive themselves to remote parking locations.[56] Downtown real estate commands premium prices, so it seems likely that many sites currently devoted to parking will be repurposed for more remunerative commercial and residential purposes.[57] Existing surface lots in the central business district can be improved and used for commercial purposes, and multi-level parking garage structures can be modified or replaced.[58] Those few structures that continue to be used for parking will need to expand their electrical infrastructure so that they can recharge a much larger number of vehicles.[59] More generally, it seems likely that the number of charging stations and the overall capacity of the electrical grid will need to grow substantially.[60]

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55. In 2018, 85.3 percent of U.S. workers commuted to work by private vehicle, 76.3 percent of them driving alone and 9.0 percent carpooling. Romic Aevaz, *2018 ACS Survey: While Most Americans' Commuting Trends are Unchanged, Teleworking Continues to Grow, and Driving Alone Dips in Some Major Cities*, ENO CTR. FOR TRANSP. (Oct. 18, 2019), https://www.enotrans.org/article/2018-acs-survey-while-most-americans-commuting-trends-are-unchanged-teleworking-continues-to-grow-and-driving-alone-dips-in-some-major-cities/ [https://perma.cc/W6KF-E6UR] (citing and summarizing U.S. Census Bureau figures). In only two of the fifteen largest metropolitan areas—New York and San Francisco—did fewer than 70% of workers commute by private vehicle (alone or in a carpool). *Id.*

56. *See* LITMAN, *supra* note 36, at 30 (observing that these facilities will likely provide charging and cleaning capabilities).

57. *See, e.g.*, David Kidd, *The Parking Garages of the Future*, GOVERNING (Aug. 2019), https://www.governing.com/topics/transportation-infrastructure/gov-garages.html [https://perma.cc/2GZA-VV7A] ("Recently rechristened 'Broadway Autopark,' Knightley's Garage [in Wichita, Kansas] today is home to 44 one-bedroom apartments, each about 700 square feet, with a covered terrace.").

58. *See* Fox, *Influence*, *supra* note 41, at 17 (noting that parking in the urban core may account for as much as 15-20% of land use).

59. AM. PLANNING ASS'N, PREPARING COMMUNITIES FOR AUTONOMOUS VEHICLES 17 (Jennifer Henaghan ed., 2018), https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/Autonomous-Vehicles-Symposium-Report.pdf [https://perma.cc/DX4F-MWEC] [hereinafter APA, PREPARING COMMUNITIES].

60. *See* Lawrence Ulrich, *'Charger Desert' in Big Cities Keeps Electric Cars from Mainstream,* N.Y. TIMES (Apr. 16, 2020), https://www.nytimes.com/2020/04/16/business/electric-cars-cities-chargers.html

The ability of these "free range" vehicles to conduct themselves to a storage facility has two related implications for land use patterns in metropolitan areas. First, as just noted, it will free up desirable downtown locations for more intensive uses. Second, it will cause lower-value land on the periphery to become more popular as sites for parking.[61] This parking transition will also have environmental consequences. Once remote space that is currently vacant is converted into parking facilities, AVs will need to make an additional round-trip every day, from the occupant's workplace to the remote parking site and back. The price for freeing up valuable downtown land will be an increase in total daily mileage. Another possibility is that fleets will replace individual ownership. Under this model, the vehicle will depart to pick up its next passenger, in effect converting many of today's vehicles into driverless Ubers.[62]

2. Building Entrances and Drop-Off Areas

Building entrances will have to be redesigned to reflect these changes. Many of today's urban structures have grand front entrances that are used only by transient visitors coming in from the street.[63] Regular occupants, meanwhile, drive into a garage that is integrated into the structure of the main building and enter that building by elevator; park in a garage that is connected to the building by a pedestrian bridge; or park near the building and enter through a secondary doorway. When AVs replace today's Level 0 and 1 cars and trucks, every vehicle will leave its occupants at a designated drop point and then head off to park itself or pick up its next passenger. This means that one or more building entrances will need to be devoted to vehicles that stop for less than a minute and then depart. These vehicles then will reverse the process later in the day, although the pickup may also involve a brief wait for the passengers to arrive.

As a result of these changes, new commercial and residential buildings may come to resemble today's elementary schools or center-city hotels, most of whose occupants are dropped off and picked up with no need to stow vehicles onsite or nearby.[64] Vehicle parking will be

[https://perma.cc/TT4D-Q4NZ] ("The real deal-killer, especially for city and apartment dwellers, is a dearth of chargers where they park their cars.").

61. These sites may need to be relatively close to their occupants, to reduce waiting time for pickups. *See* LITMAN, *supra* note 36, at 30.

62. *See infra* note 150 and accompanying text.

63. My own law school has a beautiful front entrance facing a busy roadway with no space for vehicles to discharge passengers. I doubt that I use that entrance more than once or twice every month, and only when I am leaving the building on foot for another destination on campus. I park in a multi-level garage behind the building and use the less grand rear door at least twice every business day.

64. *See, e.g.*, Anthony Flint, *We're Redesigning Our Streetscape–But What if We're Getting It All Wrong?*, BOSTON GLOBE (Apr. 22, 2019), https://www.bostonglobe.com/ideas/2019/04/22/redesigning-our-streetscape-but-what-

reduced, at least in the vicinity of the building, while stopping and standing will rise correspondingly. Architects likely will reduce or eliminate entrances designed to be used by workers who have parked nearby and add one or more driveways or curb cuts at which vehicles can stop, discharge their passengers quickly or wait briefly to pick them up, and proceed onward. Perhaps some existing parking space can be converted to loading and unloading zones, but little of that square footage will be needed for this purpose.

3. Vehicle Miles Traveled

The total amount of driving will almost certainly change, which will have huge impacts on traffic flow and the need for roadway construction.[65] It is difficult, however, to predict just how much vehicle volume and total vehicle miles traveled will change, or even in which direction.[66] Many vehicles will move themselves around while empty. Optional trips and trips that do not require a vehicle occupant, such as pickups and deliveries, may be postponed until off-peak travel times. Driving may end up being spread out more evenly throughout the day, with vehicle routing staggered to minimize congestion.

In some ways, the increased use of AVs is likely to reduce traffic.[67] Trips will become quicker, as new software allows vehicles to avoid mishaps by communicating with one another, coordinating their movements, and learning from the past experience of other vehicles.[68]

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getting-all-wrong/BvTM8jlcbTSOOeWrJuOuXI/story.html [https://perma.cc/X2JN-NXJ2] ("Mayor Martin J. Walsh recently took an incremental step when he established drop-off zones for Uber and Lyft in congested areas around Fenway Park.").

65. Changes in vehicle miles traveled might also impact roadway fatalities and injuries. *See, e.g.*, John Manuel Barrios et al., *The Cost of Convenience: Ridehailing and Traffic Fatalities* 1 (Becker Friedman Inst. Working Paper No. 2019-49), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3288802 [https://perma.cc/ZN25-6YRN] (concluding that the increase in vehicle miles traveled caused by ride-hailing companies has led to a 3% increase in fatalities). The fact that more mileage leads to more deaths with drivers involved does not necessarily imply that more mileage will lead to more deaths when the vehicles can drive themselves.

66. It is sobering to note, however, that rideshare services such as Uber and Lyft "have added 5.7 billion miles of driving annually" in nine large, densely populated American cities. BRUCE SCHALLER, SCHALLER CONSULTING, THE NEW AUTOMOBILITY: LYFT, UBER AND THE FUTURE OF AMERICAN CITIES 2 (2018), http://www.schallerconsult.com/rideservices/automobility.pdf [https://perma.cc/Z2J3-7L2V]. It appears that most of these miles would otherwise have been covered by mass transit, bicycling, and walking. *Id*

67. *An Exciting Time for Safety and Autonomous Vehicles*, U.S. DEPT. OF TRANSP.: CONNECTIONS (June 7, 2017), https://www.transportation.gov/connections/exciting-time-safety-and-autonomous-vehicles [https://perma.cc/8Y4V-X8TZ] ("American motorists currently spend more than 6.9 billion hours a year sitting in traffic, according to the American Society of Civil Engineers. That amounts to more than $300 billion in wasted time and fuel.").

68. NHTSA, ACCELERATING, *supra* note 9, at 5 ("While a human driver may repeat the same mistakes as millions before them, an HAV [highly automated vehicle] can benefit from the data and experience drawn from thousands of other vehicles on the road.").

Cars and trucks will dart around each other at intersections and merge without necessarily having to stop or even slow down, knowing full well that they will not collide.[69] If congestion begins to arise, AVs can reroute themselves along less crowded routes, as today's navigation systems already encourage some human drivers to do. The reduction in collisions will largely eliminate the sudden unexpected backups that waste driver time every day, not to mention the time and emotional energy needed to deal with property damage, personal injury, and worse. These changes should increase average travel speeds but will not necessarily reduce total distance traveled.[70]

At the same time, AVs will have reasons to travel more miles every day. Autonomous vehicles will drive additional miles as they drop their passengers, move themselves unoccupied to storage facilities, and then reverse the process just before the evening rush hour. Thus, we will be consuming energy, putting wear-and-tear on vehicles, and clogging roadways with AVs that are empty.[71] If vehicles can cover more distance in the same amount of time, people may drive further: A commuter who wants to buy a home no more than thirty minutes from her workplace may end up covering twelve miles each way instead of eight when the vehicle is conducting itself so seamlessly. The fact that driving time will become more pleasant and useful and less stressful may induce people to drive more, particularly affluent commuters.[72] That same commuter may be willing to endure a sixty-minute trip if she can use her time productively.[73] Conversely, an increase in AVs could lead to denser downtowns with reduced speed limits.[74] Vehicle

69. *See infra* note 128 (discussing slot-based intersections).

70. Then again, these changes may not increase average travel speeds. *See* Jeff Speck, *Ten Rules for Cities about Automated Vehicles*, CONGRESS FOR NEW URBANISM: PUBLIC SQUARE (Feb. 27, 2020), https://www.cnu.org/publicsquare/2020/02/27/ten-rules-cities-about-automated-vehicles [https://perma.cc/EU2W-TYF3] [hereinafter Speck, *Ten Rules*] ("We travel no faster in cities than we used to with the horse and buggy.").

71. Boston's Logan Airport now requires all transportation network company passengers to board and drop at a centralized location, away from the terminal, with the goal of ensuring that fewer drivers carry passengers in only one direction. *See* Benjamin Swasey, *Why Logan Airport Wants To Change Where Your Lyft Or Uber Drops You Off*, WBUR: BOSTONOMIX (Apr. 17, 2019), https://www.wbur.org/bostonomix/2019/04/17/logan-airport-ride-hailing-proposal [https://perma.cc/9GUQ-NKHB] (observing that in 2018, ride-hailing services took 12 million trips to and from Logan, 5 million of those with no passengers).

72. *See, e.g.*, Tracey Lindeman, *Ride-Hailing is Deepening Social and Economic Inequity in the US*, VICE (Feb. 10, 2018, 9:00 AM), https://www.vice.com/en_us/article/wj4n8q/uber-lyft-are-making-public-transit-worse-ridesharing-cities [https://perma.cc/VYB4-7UKJ] ("[T]he people who are choosing to ditch public transit in favor of ridesharing, ride-hailing, and car-sharing (and autonomous cars, if and when they come) tend to be higher-income people who would have otherwise paid full price for their transit fares.").

73. *See* Fox, *supra* note 27 at 157, 167-69 (describing the relationship between vehicle ownership and sprawl). Note that the real estate industry is likely to applaud this change, as more far-flung land will now fall within acceptable commuting time.

74. DOROTHY J. GLANCY ET AL., NATIONAL COOPERATIVE HIGHWAY RESEARCH PROGRAM: A LOOK AT THE LEGAL ENVIRONMENT FOR DRIVERLESS VEHICLES 76 (2016),

occupants may have less incentive and less desire to use vehicles and those vehicles may cover fewer total miles.[75]

Thus, while total mileage and roadway usage will almost certainly change when AVs become prevalent, it is difficult to predict whether they will increase or decrease overall. The type of driving we do now will become more efficient, with more effective routing and quicker trips. However, other types of driving—particularly the movement of vehicles without occupants—will either increase or arise anew. It seems plausible that the total number of vehicle miles traveled will increase. However, citizens of 2050 may find this type of rash prediction to be as laughable as we find earlier predictions of the paperless office.[76]

4. "Road Diets"

Many automotive engineering experts already predict that traffic lanes will become considerably narrower. To begin with, AVs swerve and veer within a traffic lane far less than vehicles driven by humans, given that they are not prone to distraction.[77] In addition, AVs eventually will react to obstacles more quickly than human drivers do.[78] The typical highway lane, which is about twelve feet wide, can be reduced to a width of nine feet.[79] If this prediction proves accurate, a current three-lane road that is thirty-six feet wide can be transformed into a

https://transops.s3.amazonaws.com/uploaded_files/A%20Look%20at%20the%20Legal%20Environment%20for%20Driverless%20Vehicles.pdf [https://perma.cc/SLT7-CSSV] ("[T]o the extent that driverless vehicles are deployed as low-speed vehicles permitted only in urban areas, driverless vehicles could incentivize more dense residential land development patterns.").

75. *See id.* at 76-77.

76. *See, e.g.*, Steve Earle, *21st Century Blues*, AZLYRICS.COM (2013), https://www.azlyrics.com/lyrics/steveearle/21stcenturyblues.html [https://perma.cc/ZNG6-82AL] ("No man on the moon, nobody on Mars/Where the hell is my flying car?") (last visited Sept. 6, 2020).

77. One author refers to some of today's motor vehicle operators as "zombie drivers." DAN ALBERT, ARE WE THERE YET?: THE AMERICAN AUTOMOBILE PAST, PRESENT, AND DRIVERLESS 10 (2019).

78. Impaired driving will become a thing of the past, and restaurants and bars will be able to sell more alcohol. Geoff Nesnow, *73 Mind-Blowing Implications of Driverless Cars and Trucks*, MEDIUM (Feb. 9, 2018), https://medium.com/@DonotInnovate/73-mind-blowing-implications-of-a-driverless-future-58d23d1f338d [https://perma.cc/YW8E-755Y].

79. Jeff Speck, *Nine Keys to Safe Downtown Streets*, CONGRESS FOR NEW URBANISM: PUBLIC SQUARE (Jan. 7, 2020), https://www.cnu.org/publicsquare/2020/01/07/nine-keys-safe-downtown-streets [https://perma.cc/8AUH-2SV2] (comparing the widths of urban and highway lanes); Tom Sohrweide, *Driverless Vehicles Set to Change the Way We Design Our Roadways?*, SEH (Jul. 25, 2018), http://www.sehinc.com/news/future-what-do-driverless-cars-mean-road-design [https://perma.cc/4J67-94PL] (observing that, for autonomous vehicles, "lanes likely wouldn't need to be much wider than a delivery truck"); Ryan Snyder, *Street Design Implications of Autonomous Vehicles*, CONGRESS FOR NEW URBANISM: PUBLIC SQUARE (Mar. 12, 2018), https://www.cnu.org/publicsquare/2018/03/12/street-design-implications-autonomous-vehicles [https://perma.cc/KNE3-LR3U] ("As AVs will be better able to stay in lanes, those without full-size passenger buses or trucks could be reduced to 8 or 9 feet in width.").

four-lane road that is still thirty-six feet wide with little more than some white paint, and driverless cars may not even need the paint.[80] Rather than adding a fourth lane, the local government might decide instead to maintain the current traffic load and narrow the road by nine feet, thereby freeing up a strip of land for other uses. Moreover, vehicles will be able to drive closer together within a lane, tailgating safely, given that drivers will no longer surprise other drivers with unexpected maneuvers. This means that any given lane, even a narrower one, can handle additional capacity.[81]

Surplus road width can be repurposed in a variety of different ways. It could be dedicated to mass transit, such as buses or light rail. It can be transformed into a high-occupancy vehicle lane to encourage carpooling. It might be restricted to cyclists and pedestrians. It could be landscaped and used as green space, shielding pedestrians on the sidewalk from fast-moving vehicles and enhancing visual attractiveness. It might be reconfigured and redeveloped. If cities use these ribbons of former roadway space for landscaping, infill development, or expansion of retail onto the sidewalk, it will transform the physical appearance and the overall dynamic of urban downtowns. The city of the future may bear little resemblance to today's legacy cities.

5. Vehicle Sharing and Mass Transit

Ride-sharing is already on the rise, and companies such as Uber and Lyft have quickly revolutionized patterns of vehicular ownership, particularly in densely populated urban areas.[82] Those in need of local transportation have become more comfortable with the idea of summoning a total stranger to pick them up at Point A and drop them at Point B.[83] Drivers, similarly, have become more accustomed to the idea of transporting travelers they do not know, for a fee.[84] This means that those who need a vehicle only occasionally are more apt to hire someone else's car when needed rather than acquiring their own, and

80. SCHWARTZ, *supra* note 1, at 8.

81. *Id.* at 46 ("Because AVs can travel more closely together, effectively in platoons, vehicular capacity could increase by 50 to 100 percent, or even more.").

82. *Id.* at 4 ("It's hard to fault cities for not having sufficient foresight about app-based transportation, since no one had an inkling, including me, that people would change their travel habits so quickly and dramatically.").

83. *See id.* at 4-5 ("When AVs become the norm, the reverberations will make app-based rides on demand seem like a minor blip on the transportation landscape.").

84. One comedian has referred to traveling by Uber as "hitchhiking with your phone." PMMI: The Association for Packaging and Processing Technologies, *Sebastian Maniscalco - Uber Skit*, YOUTUBE (May 23, 2018), https://www.youtube.com/watch?v=t_PsVW2F6WQ [https://perma.cc/2A27-KCCE].

those who are struggling to afford a car may serve as short-term drivers to help make ends meet.[85]

Instead of each person owning a vehicle that sits empty most of the day, networks of drivers and passengers who are strangers to one another currently can use an app on their smartphone to coordinate rides, times, and fares in seconds. This could reduce the number of vehicles on the road, as some people who formerly would have owned a vehicle will now share cars belonging to others. Alternatively, owners might retain their personal vehicles while employing ride-sharing services some of the time, thereby increasing the total number of vehicles owned.[86] Even if the growth of ride-sharing has increased the total number of vehicle-miles traveled, it might lead to fewer cars on the road and greater efficiency in the use of each vehicle, with cars spending less time idle.[87] In addition, there is evidence that the growth of ride-sharing displays generational characteristics, with younger adults less likely to own vehicles than their parents and grandparents.[88] Possible reasons for this trend include cost, convenience, and, even before the COVID-19 pandemic, the ability to work online.[89] If these reasons are accurate, today's trends are likely to intensify in the coming years.

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85. There is also evidence that some two-car families are becoming one-car families. *See, e.g.*, *Demographic Shifts: Shaping the Future of Car Ownership*, WHARTON: UNIVERSITY OF PENNSYLVANIA: KNOWLEDGE@WHARTON (Feb. 21, 2017), https://knowledge.wharton.upenn.edu/article/demographic-shifts-shaping-future-car-ownership/ [https://perma.cc/2FP3-5WRT] (noting that many baby boomers are moving to urban areas and seeing less need to own a private car).

86. Either way, total miles traveled might increase. After all, if the total number of miles to be traveled remains the same and some vehicles are now also cruising between fares, drivers are adding mileage overall. We may end up with fewer vehicles on the road but each one driving more miles. If current users of mass transit migrate to ride-sharing, then both the number of vehicles on the road and vehicle-miles traveled might grow even further.

87. *See* Fox, *Influence*, *supra* note 41, at 11-12 (predicting a 50% drop in the number of motor vehicles needed).

88. *See* Kathleen McCormick, *Driverless Ed: Urban Planners Shift Gears as Autonomous Vehicles Hit the Streets*, LAND LINES, Apr. 2019, at 20, 22, https://www.lincolninst.edu/sites/default/files/pubfiles/driverless-ed-lla190404.pdf [https://perma.cc/3TZD-BAUR] ("[I]n a recent consumer survey by Arity, a data start-up launched by Allstate, 59 percent of respondents between 22 and 37 years old say they'd rather spend time doing more productive tasks than driving, 51 percent don't think owning a car is worth the investment, and 45 percent regularly use ride-hailing services.") (citation omitted); *Owning Fewer Cars Isn't Just for Millennials*, U.S. PUB. INT. RES. GRP.: BLOG (Mar. 29, 2016), https://uspirg.org/blogs/blog/usp/owning-fewer-cars-isn%E2%80%99t-just-millennials [https://perma.cc/PGT7-ZQQ8] (observing that those who use shared transportation services, which are popular among millennials, own cars at lower rates than others). *But see* Meredith Somers, *Actually, Millennials Don't Own Fewer Cars*, MIT MGMT. SLOAN SCH.: IDEAS MADE TO MATTER (Apr. 24, 2019), https://mitsloan.mit.edu/ideas-made-to-matter/actually-millennials-dont-own-fewer-cars [https://perma.cc/S4AM-EX3G] (finding that millennials own the same number of cars and drive 2,234 more miles per year than baby boomers).

89. Brandon Schoettle & Michael Sivak, *The Reasons for the Recent Decline in Young Driver Licensing in the U.S.*, UNIV. MICH. TRANSP. RES. INST. 4-12 (2013),

The growth in AVs will likely affect mass transit ridership as well. Every traveler must choose among competing transportation options, and the addition of autonomous alternatives will likely make buses and trains less appealing to at least some current passengers.[90] People who do not wish to use their own cars for a trip (or walk or bicycle) now can choose between mass transit options, which are usually cheaper but slower, and taxis, which are costlier but, in many cases, quicker. Ride-sharing alternatives have already reduced the attractiveness of taxis, lowering owner and driver revenues and the value of a taxi medallion.[91] They are also inexpensive enough to persuade some riders to leave buses and trains. Neither ride-sharing nor AVs, however, will ever be able to carry enough passengers to supplant mass transit fully, particularly in the most densely packed cities.[92] In addition, travelers will end up walking less if AVs displace some mass transit riders, since they no longer have to walk to and from a bus or train stop at each end of their ride.[93]

If ride-sharing vehicles transition to full autonomy, they will become even cheaper to operate, at which point the number of riders who abandon mass transit will likely increase. At that point, the primary users of mass transit will mostly likely be those who are unable to afford any of the alternatives.[94] Of course, mass transit vehicles, particularly buses, will likely become autonomous at the same time. A greater mix of autonomous mass transit vehicle sizes may make this option more appealing to some travelers: An

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https://deepblue.lib.umich.edu/bitstream/handle/2027.42/99124/102951.pdf?sequence=1 [https://perma.cc/4UZ6-BE72] (listing these and other reasons that younger people do not obtain licenses).

90. Mass transit, though environmentally friendlier than private automobiles, has been widely shunned during the COVID-19 pandemic. *See, e.g.*, Alex Marshall, *How Much Does Transit Spread COVID-19? The Jury Is Still Out*, GOVERNING (May 29, 2020), https://www.governing.com/now/How-Much-Does-Transit-Spread-COVID-19-The-Jury-Is-Still-Out.html [https://perma.cc/8QEX-NTG6] (noting that, "[w]hat is needed are some good studies on how much mass transit and density spread disease and, if they do, how it can be countered" while also acknowledging that "Staten Island, the most suburban part of [New York City] with the least transit use, has one of the city's highest rates of confirmed cases, as do less-dense parts of Queens").

91. Gregory M. Stein, *Inequality in the Sharing Economy*, 85 BROOK. L. REV. 787, 828 (2020) (examining the drop in the price of New York City taxi medallions since ride-sharing has become popular).

92. *See* Emily Badger, *Pave Over the Subway? Cities Face Tough Bets on Driverless Cars*, N.Y. TIMES (July 20, 2018), https://www.nytimes.com/2018/07/20/upshot/driverless-cars-vs-transit-spending-cities.html [https://perma.cc/GS86-RSVU] ("No system of autonomous cars could be more efficient than the New York subway, said Andrew Salzberg, Uber's head of transportation policy and research.").

93. APA, PREPARING COMMUNITIES, *supra* note 59, at 5 (noting that "[i]f people rely on AVs for door-to-door transportation, they may walk less," and expressing concern that this will reduce demand for sidewalks and crosswalks, thereby exacerbating the problem).

94. *See* SCHWARTZ, *supra* note 1, at 189-90 (observing how the growth of AVs may exacerbate existing income inequality).

autonomous taxi or small bus holding four, eight, or ten passengers will make fewer stops than a traditional bus and may appeal to an entirely new ridership.

B. Less Obvious Land Use Issues

Once we recognize these fairly obvious land use issues that planners will have to address as AVs begin to replace older vehicles, we next need to consider second-order problems that will arise. The line I draw here between "obvious" and "less obvious" is an arbitrary one, but this second group of issues seems like the type that will occur to planners only later on, after they have begun responding to the more apparent consequences discussed in the previous Section.

1. Repurposing of Older Facilities

Some existing structures will become obsolete even though they otherwise would have had many years of useful life ahead of them. Rather than removing these structures, some owners—both public and private—will try to think of creative ways to reuse them. This is particularly true of newer parking garages located in downtown areas. Some of these garages are free-standing structures, located near commercial and residential buildings. These structures could be gutted or replaced, but this would be quite costly. In other cases, garages are incorporated into the lower levels of the buildings themselves, which means that the structures contain integrated parking space they no longer need but that cannot simply be removed.[95] Some roadway areas may also become obsolete, including connectors to parking areas and strips of roadway previously devoted to on-street parking.

Architects have already begun to ponder this issue and are "future-proofing" new parking structures with an eye toward reuse.[96] Some newer garages have flat floors rather than sloping, corkscrew designs, with an eye toward later commercial or residential operation.[97] These garages have higher ceiling heights than is typical, with upper levels accessible by ramps affixed to the structure's exterior that can be

95. *See infra* notes 169-74 and accompanying text (discussing parking requirements in Austin, Texas).

96. Joe Pobiner, *Six Urban Design Trends to Watch in 2018*, GENSLERONCITIES (Jan. 30, 2018), http://www.gensleron.com/cities/2018/1/30/six-urban-design-trends-to-watch-in-2018.html [https://perma.cc/ZX2Z-6SBZ]. The author suggests that the U.S. has already achieved "peak parking." *Id.*

97. Lisa Prevost, *On the College Campus of the Future, Parking May Be a Relic*, N.Y. TIMES (Sept. 5, 2017), https://www.nytimes.com/2017/09/05/business/college-campus-parking.html?partner=rss&emc=rss&_r=0 [https://perma.cc/KRP9-G6K2] (describing how universities can build parking with an eye toward future retrofits).

removed when no longer needed.[98] This type of design may pay off when demand for downtown parking drops precipitously, though it is costlier in the short run.[99] Additionally, "[a]rchitecture firm Gensler . . . is working on ways to turn garages into affordable housing . . . by building modular units that can fit into existing structures."[100]

2. Re-engineering Roadways

The roads of the future can be engineered quite differently from today's roads once vehicles are autonomous and there is no need for on-street parking. Lanes can be narrower, since autonomous vehicles do not drift sideways and wobble when the "driver" is responding to a text or eating an Egg McMuffin.[101] Many on-street parking lanes will disappear as vehicles can conduct themselves to more remote storage facilities.[102] Some commuters may opt for fleet vehicles, carpooling, mass transit, motorcycles, bicycles, or walking.[103] Designers thus will be able to dispense with some of the features of today's roadways. They will also need to introduce new ones, such as massively expanded drop-off areas.[104] As roads become narrower, less urban surface may remain paved, thereby reducing water runoff.[105]

High-speed roadways may also need to be modified.[106] If truck platooning becomes prevalent, acceleration and deceleration lanes

98. *Id.*; Sonja Jerše, *Design Garages so They Can Easily Become Housing!*, MODELUR (Aug. 14, 2018), https://modelur.eu/design-parking-garages-so-they-can-easily-become-housing/ [https://perma.cc/KM9F-DF2Q] ("The slopes that connect the floors should be designed in such a way that they can be easily removed in the future.").

99. *Id.* (noting that this type of design may add 10 to 15 percent to initial construction costs).

100. *Self-driving Cars Could Kill Parking Garages. Here's How Developers are Responding*, REALDEAL (Jan. 31, 2018, 11:00 AM), https://therealdeal.com/2018/01/31/self-driving-cars-could-kill-the-parking-garage-heres-how-developers-are-responding/ [https://perma.cc/3ULQ-Y2UG]; *see also* Kidd, *supra* note 57.

101. *See supra* Section II.A.4.

102. *See supra* Section II.A.1.

103. One expert predicts that the growth of AVs will lead to the extinction of motorcycles. Motorcycle usage is already dropping and is largely the province of older white men. AV technology has difficulty recognizing and responding to motorcycles, which could render them even more dangerous than they presently are. In addition, it is hard to imagine a market for autonomous motorcycles, since those who drive motorcycles largely want to be *driving* a motorcycle. *See* SCHWARTZ, *supra* note 1, at 112-13 (addressing motorcycles).

104. *See supra* Section II.A.2.

105. Jason Henderson & Jason Spencer, *Autonomous Vehicles and Commercial Real Estate*, 14 CORNELL REAL EST. REV. 44, 50 (2016), https://scholarship.sha.cornell.edu/crer/vol14/iss1/14/ [https://perma.cc/22SU-FDT3] ("Within CBDs [central business districts], increasing the ratio of permeable surfaces to total surface area should increase the volume of storm water runoff that is absorbed and filtered by the underlying soil. As a result, cities will be able to forgo expanding existing or building new storm water treatment systems.").

106. Autonomous trucks could become prevalent on American roads before autonomous cars, given that they mostly engage in less complex driving on high-speed roadways. *See, e.g.*, Conor Dougherty, *Self-Driving Trucks May Be Closer than they Appear*, N.Y. TIMES

may need to be lengthened substantially.[107] Engineers will have to contend with the fact that it takes longer to pass a convoy of ten closely packed trucks—in effect, a ten-truck train—and will need to reconsider total separation of personal automobiles from freight vehicles. Even today, some roads contain dedicated truck lanes, a feature that may become much more common.[108] Conversely, autonomous vehicles may need shorter merge lanes, since vehicles that are entering the road can coordinate automatically with those already on the highway.[109] Jurisdictions will also have to reckon with the fact that it is far more difficult to reconfigure existing roads, particularly in crowded downtown areas, than it is to design new ones to rapidly evolving standards. Thus, Las Vegas will enjoy more flexibility and opportunity to experiment than Boston.

3. AV Hardware and Bandwidth

Autonomous vehicles will need to communicate with each other and with fixed-location hardware on an ongoing basis.[110] As a vehicle approaches an intersection, for example, it must transmit its location, speed, and destination to a central location and to nearby vehicles, and the central location will need to determine a sequence and speed of

(Nov. 13, 2017), https://www.nytimes.com/2017/11/13/business/self-driving-trucks.html [https://perma.cc/6THG-XLAH] ("Unlike autonomous cars, which face questions about navigating chaotic urban streets, trucks spend a lot of time heading straight on desolate highways. And while the advent of the self-driving car will rest on the decisions of individual consumers, logistics companies are unemotional operators that will upgrade their fleets the moment it makes financial sense."). The more complicated first and last few miles of every truck trip could be navigated by operators controlling the trucks from remote offices, much like drone pilots. *Id.*

107. *See infra* Section II.B.7 (addressing truck platooning in more detail).

108. *See, e.g.*, *Corridors of the Future: Fact Sheet: CORRIDOR: Interstate 70 (I-70): Dedicated Truck Lanes - Missouri to Ohio*, FED. HIGHWAY ADMIN.: BRIEFING ROOM, PRESS RELEASES (Sept. 14, 2012), https://www.fhwa.dot.gov/pressroom/fsi70.cfm [https://perma.cc/BQN4-B38B] (proposing four dedicated truck lanes along a 750-mile stretch of Interstate 70).

109. *See supra* notes 33, 67-70 and accompanying text.

110. Without getting into the technological weeds more than necessary, it is worth noting here that AVs will most likely require both vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) technology. The former allows vehicles to communicate directly with one another to coordinate their movements. *See Vehicle-to-Vehicle Communication*, NAT'L HIGHWAY TRAFFIC SAFETY ADMIN.: TECH. & INNOVATION, https://www.nhtsa.gov/technology-innovation/vehicle-vehicle-communication [https://perma.cc/HY6X-4BAZ] (last visited Dec. 28, 2020) ("Vehicle-to-vehicle (V2V) communication enables vehicles to wirelessly exchange information about their speed, location, and heading"). The latter serves a control tower function, coordinating larger numbers of vehicles. *See* Terry Costlow, *As V2I Evolves, Costs, Maintenance Concerns Emerge*, SAE INT'L (Apr. 5, 2017), https://www.sae.org/news/2017/04/as-v2i-evolves-costs-maintenance-concerns-emerge [https://perma.cc/S9FX-9RZL] (noting that "V2I is expected to be a necessity for autonomous vehicles, since roadside beacons can provide information that augments data supplied by on-vehicle sensors" and expressing concerns about the cost).

passage almost instantaneously.[111] This may lead to the disappearance of traffic signals and stop signs, but it will create a corresponding need for hardware and software that allow this communication to occur rapidly and continuously. The system fails if there is insufficient equipment and bandwidth to handle peak traffic. Public acceptance of AVs will evaporate if every approach to an intersection leads to the equivalent of a small wheel spinning on a screen and a webpage that never loads.

Tens of millions of pieces of equipment, ranging from cameras to radar and lidar sensors to routers to servers, will need to be placed along roadways at regular intervals and at all intersections, with adequate backups in case of service outages.[112] It is not clear who will be responsible for placing all of this equipment. State or local governments, public or private utilities, automobile manufacturers, telecommunications companies, hardware manufacturers, software manufacturers, entirely new enterprises, or subcontractors of any of the above may be responsible for these installations. One can easily imagine a network that is developed, installed, and controlled by Toyota or Verizon or Dell or Microsoft or Google or a company that has not yet been incorporated, and it is possible that competing networks will co-exist and interface with one another, as they do for mobile communications today. As with all hardware and software, upgrades will be necessary on a regular basis, as technology and traffic patterns evolve and security problems emerge. Given how new much of this technology is, it will be hard to find enough experts to meet demand.[113]

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111. *See, e.g.,* Jamie Carter, *Hacked Driverless Cars Could Cause Collisions and Gridlock in Cities, Say Researchers*, FORBES (Mar. 5, 2019, 5:46 AM), https://www.forbes.com/sites/jamiecartereurope/2019/03/05/hacked-driverless-cars-could-cause-collisions-and-gridlock-in-cities-say-researchers/#5e26d80a2a09 [https://perma.cc/WCG8-X4EU] ("Whereas . . . 4G has a latency of 40 milliseconds, it's just one or two milliseconds on a 5G connection, making real-time vehicle-to-vehicle communications possible.").

112. Donald F. Kettl, *Little Boxes Everywhere*, GOVERNING (Aug. 26, 2019), https://www.governing.com/columns/washington-watch/gov-5G-local-government-struggles.html [https://perma.cc/7SYK-4LT7] (observing that AVs will likely run on 5G technology, which will require installation of perhaps one million short-range "mini-towers" along with a network of thick fiber-optic cables, at a total cost that may run to $150 billion). There is some disagreement as to whether sophisticated software may permit AV deployment before the infrastructure is fully established. *See, e.g.*, Faiz Siddiqui, *Tesla Is Putting 'Self-Driving' in the Hands of Drivers Amid Criticism the Tech Is Not Ready*, WASH. POST: TECH. (Oct. 22, 2020), https://www.washingtonpost.com/technology/2020/10/21/tesla-self-driving/ [https://perma.cc/M6SL-6VXD] (noting that "Tesla is aiming to compensate for its hardware limitations by supercharging its software, almost to create a virtual lidar using Tesla's existing suite of cameras" and reporting criticism of this approach).

113. *See, e.g.*, Johana Bhuiyan, *Ex-Googler Sebastian Thrun Says the Going Rate for Self-Driving Talent is $10 Million Per Person*, VOX: RECODE (Sept. 17, 2016), https://www.vox.com/2016/9/17/12943214/sebastian-thrun-self-driving-talent-pool [https://perma.cc/J6E9-3L2J] ("It's why Tesla, Google, Apple and Faraday Future are constantly poaching engineers from each other and why Uber ransacked Carnegie Mellon's famed robotics lab. There simply aren't enough people who are equipped with the knowledge and skills required to automate a vehicle.").

Placement of much of this equipment will require the negotiation of leases, licenses, and easements.[114] Governments or utilities that believe they can place this equipment along existing rights-of-way may learn that this installation exceeds the scope of previously negotiated property rights.[115] Governments or utilities may need to exercise their condemnation power to be able to install this equipment, much as they did when installing the cable television network several decades ago.[116] Siting of this equipment may also violate covenants enforced by homeowners' associations, condominiums, and cooperatives, which will need to be brought onboard.[117]

4. Cooperation among Jurisdictions

There is no guarantee that every jurisdiction installing this type of hardware and software will adopt the same technical standards or will upgrade on the same schedule.[118] This means either that the various differing specifications must be mutually compatible or that vehicles will need to know how to communicate using different standards. If neither of these things happens, then a vehicle may be unable to function when it crosses into another jurisdiction that has adopted an incompatible standard.[119] The United States also must be wary of falling out of step with international standards.[120]

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114. This may not be necessary in every case, as a city or utility may end up placing equipment it owns or controls on land it also owns or controls.

115. *See, e.g.*, Baltimore Cty. v. AT&T Corp., 735 F. Supp. 2d 1063, 1074-77 (S.D. Ind. 2010) (holding that a service provider's installation of communications cables in a railroad right-of-way exceeded the scope of the easement granted by the original underlying landowners to the railroad).

116. *See* Loretto v. Teleprompter Manhattan CATV, 458 U.S. 419 (1982) (requiring compensation for even trivial permanent physical occupations of property, including installation of cable television equipment).

117. Installing equipment of this type may also raise issues of federal pre-emption. *See* 47 C.F.R. § 1.4000 (2020) (prohibiting most restrictions on installation, maintenance, and use of antennas for receiving video programming); *Over-the-air Reception Devices Rule,* FCC, https://www.fcc.gov/media/over-air-reception-devices-rule [https://perma.cc/8ANZ-Z5WG] (last updated Sept. 1, 2020) (elaborating on this federal rule).

118. *See* Daniel A. Crane et al., *A Survey of Legal Issues Arising from the Deployment of Autonomous and Connected Vehicles*, 23 MICH. TELECOMM. & TECH. L. REV. 191, 233-39 (2017) (discussing issues of technological compatibility).

119. In the past, some nations that feared external invasion adopted unique railroad gauges so that foreign trains could not operate on domestic tracks. *See, e.g.*, *Intermodal Freight Vehicles and Systems*, ENCYCLOPEDIA BRITANNICA, https://www.britannica.com/technology/railroad/Intermodal-freight-vehicles-and-systems#ref528945 [https://perma.cc/3M77-XRAE] (last visited Oct. 10, 2020) ("It was the deliberate policy of Spain, and thereby of Portugal, to adopt a nominal gauge of 1,676 mm (5 feet 6 inches) so as to be distinct from France, a neighbour who on several occasions during the preceding century had interfered in Spanish affairs.").

120. NAT'L SCI. & TECH. COUNCIL & U.S. DEP'T OF TRANSP., ENSURING AMERICAN LEADERSHIP IN AUTOMATED VEHICLE TECHNOLOGIES: AUTOMATED VEHICLES 4.0 4-6 (2020), https://www.transportation.gov/sites/dot.gov/files/2020-02/EnsuringAmericanLeadershipAVTech4.pdf [https://perma.cc/9FK6-5DRR] (noting this issue).

Jurisdictions that adopt a standard early thus run the risk of purchasing the equivalent of a Sony Betamax.[121] If their neighbors later adopt an incompatible standard that proves to be more popular, the early adopters may find that they spent a huge amount of money on equipment that soon becomes obsolete. Conversely, jurisdictions that wait and see what their neighbors do may eventually find their choices constrained, as their own residents clamor for them to adopt a standard identical to that employed by neighboring cities. They may end up with a less desirable or more costly standard solely because they cast their ballot after the polls had effectively closed.

5. Reduced State and Municipal Revenue

Jurisdictions will lose some current revenue streams, though these could be offset by new ones.[122] Parking revenue from meters and pay stations, surface lots, and garages will disappear, at least downtown, since AVs will not park there, and so will the related income from fines and towing charges.[123] This revenue will be replaced by charges for remote parking. Because offsite parking will be in locations that are in lower demand, this revenue likely will be lower, and some of this parking may be in other jurisdictions altogether.[124]

This revenue loss may be more than replaced by the income generated from the new use to which the former parking areas are put. If a commercial office building replaces a surface lot, real estate tax and sales tax proceeds will soar. If the land is dedicated to green space, however, the in-kind benefits that result produce no direct contribution to the city's coffers, although they may enhance overall quality of life and the value of neighboring property. New revenue sources, such as pickup and drop-off fees, may offset some of these economic losses.[125] States, too, will need to find ways to replace revenues lost as AVs become more prevalent.[126]

121. *See* Erick Guerra, *Planning for Cars That Drive Themselves: Metropolitan Planning Organizations, Regional Transportation Plans, and Autonomous Vehicles*, 36 J. PLAN. EDUC. & RES. 210, 215 (2016) ("Spending millions of dollars on smart infrastructure is potentially wasteful, and no government agency wants to risk betting on a technology that flops.").

122. *See* Fox, *Influence*, *supra* note 41, at 41-43 (recommending that states adopt a tax on transportation and mobility services, a tax on vehicle miles traveled, and congestion charges).

123. *See supra* notes 46-62 and accompanying text.

124. *See supra* Section II.A.1.

125. *See supra* note 51 and accompanying text.

126. *See, e.g.*, Kaylee Tornay, *Oregon to Introduce New Car Fees as Gas Tax Is Phased Out*, GOVERNING (Nov. 23, 2019), https://www.governing.com/news/headlines/Oregon-to-Introduce-New-Car-Fees-as-Gas-Tax-Is-Phased-Out.html [https://perma.cc/5ANQ-MR23] ("Fuel-efficient and electric vehicles, which have driven a wedge in recent years into the state's gas tax-fed Highway Fund, will be subject to increased registration fees approved by the Oregon Legislature that are intended to recoup revenue losses.").

6. Removal of Traffic Signals and Road Signs

Traffic signals and road signs display the local rules of the road so that drivers can anticipate what other drivers are going to do and act accordingly. Once vehicles can communicate directly with each other and with a unique intersection manager, these visible displays will become obsolete for vehicles, though perhaps not for cyclists and pedestrians. Thus, visible signals and signs may become as irrelevant for autonomous vehicles as they are for elevator cars.[127]

Traffic will still need governing rules, but these rules will be communicated electronically. Passage through an intersection may follow patterns similar to those employed by air traffic controllers, where the control tower—analogous to the roadway intersection manager—assigns individual planes a time slot during which they have exclusive use of an airspace corridor, following which that space can be occupied by another designated plane.[128] This removes the need for driver attentiveness, reduces wait time, increases roadway capacity, and reduces emissions caused by stop-and-go traffic.[129]

7. Vehicle Platooning

Vehicle platooning allows multiple vehicles to travel together at close distances with only the first vehicle driven by a human; the remaining vehicles act in response to the lead vehicle.[130] Platooning lowers fuel consumption by reducing drag.[131] It increases safety by ensuring that all of the vehicles act in tandem.[132] Platooning also

127. Thompson, *Full Tilt, supra* note 25 (Road signs are "designed for humans, and GPS-brained robots don't need them to know where they're going.").

128. "Results theoretically show that transitioning from a traffic light system to SI [Slot-based Intersections] has the potential of doubling capacity and significantly reducing delays." Remi Tachet et al., *Revisiting Street Intersections Using Slot-Based Systems*, PLOS.ONE 1 (Mar. 16, 2016), https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0149607 [https://perma.cc/5QT4-2LT7]. This change has "the potential of significantly reducing overall congestion and improving the stability and predictability of traffic." *Id.* at 7.

129. *See id.* at 2, 3, 6, 7 (describing how all of this will result from the sharp reduction in inefficient use of the intersection).

130. *See What is Truck Platooning?*, EUR. AUTOMOBILE MANUFACTURERS ASS'N, https://www.acea.be/uploads/publications/Platooning_roadmap.pdf [https://perma.cc/UD3X-DDKR] (last visited Sept. 20, 2020).

131. Ashley Halsey III, *Are Those 80,000 Pound Trucks Tailgating Each Other? Soon it May Be Perfectly Normal–and Safe*, WASH. POST (Oct. 22, 2017), https://www.washingtonpost.com/local/trafficandcommuting/are-those-80000-pound-trucks-tailgating-each-other-soon-it-may-be-perfectly-normal--and-safe/2017/10/22/fbbbb0fa-a2de-11e7-b14f-f41773cd5a14_story.html [https://perma.cc/FDP4-3Z2Y] ("A truck tucked in the slipstream of another tractor-trailer can save 10 percent on fuel. But the truck in front also will burn about 5 percent less fuel.").

132. Vehicle manufacturer Daimler claims "that information critical to safety, e.g. recognising emergency braking when it occurs, can be transferred within 0.1 seconds and therefore very rapidly." *Highway Pilot Connect: Networked Trucks Drive in a Convoy for Greater Safety and Lower Fuel Consumption*, DAIMLER GLOBAL MEDIA SITE,

reduces haulage cost by removing drivers from all but the first vehicle in the convoy.[133] One U.S. Department of Energy laboratory has estimated that truck platooning could save as much as 1.5 billion gallons of petroleum-based fuels annually and reduce carbon dioxide emissions by 15.3 million metric tons.[134] It would also reduce highway fatalities, many of which involve trucks that kill non-occupants.[135]

Vehicle platooning relies on AV technology to allow the lead truck to transmit driving instructions to the remaining vehicles in the convoy.[136] It may lead to the need for highway redesign, since roadway lanes, particularly merge lanes and exit ramps, were not designed with such lengthy convoys in mind. Truck platooning also will hasten the day when many truck drivers need to seek alternative employment, since all but the lead truck in a platoon will be unoccupied once platooning is completely feasible.[137]

8. Other Issues that are Not Related to Land Use

The AV revolution will present additional issues that have a more tenuous relationship to land use. While some of these issues go well beyond the scope of this Article, it is not always easy to separate land use effects from others. Thus, several of these more tangential issues merit brief discussion here.

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https://media.daimler.com/marsMediaSite/en/instance/ko/Highway-Pilot-Connect-networked-trucks-drive-in-a-convoy-for-greater-safety-and-lower-fuel-consumption.xhtml?oid=9905211 [https://perma.cc/8G2V-YZTN] (last visited Mar. 6, 2020). Daimler's media site proceeds to note, "If the lead vehicle or another vehicle in the platoon brakes, all the following vehicles are also braked automatically." *Id.*

133. Halsey, *supra* note 131; *see also Truck Platooning*, NAT'L RENEWABLE ENERGY LABORATORY, https://www.nrel.gov/transportation/fleettest-platooning.html [https://perma.cc/QY84-N5HQ] (last visited Sept. 3, 2020) ("NREL analyzed 3 million miles of high-resolution data and found that about 65% of the total miles driven by [certain commercial freight] trucks could be driven in platoon formation—leading to a 4% reduction in total truck fuel consumption and significant cost savings for truck operators.").

134. Matteo Muratori et al., Nat'l Renewable Energy Laboratory, *Potentials for Platooning in U.S. Highway Freight Transport*, 10 SAE INT'L J. COMM. VEHICLES 45, 48 (2017).

135. In 2016, 83% of the 4,317 fatalities in vehicular crashes involving large trucks were not occupants of those trucks. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., DOT HS 812 451, QUICK FACTS 2016, at 5, https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812451 [https://perma.cc/36RP-Q9KX] (noting that 72% were occupants of other vehicles and 11% were not occupants of any vehicle) (last updated Feb. 2018).

136. *Safety & Efficiency: Truck Platooning*, PELOTON TECH., https://peloton-tech.com/ [https://perma.cc/Y6ZC-LLKW] (last visited Dec. 28, 2020).

137. Even today, before the full deployment of AV technology, platooning is available and leads to fuel savings. However, today's rudimentary platooning requires that a driver maintain primary control of every truck. *See, e.g., id.*; *see also Platooning Trucks to Cut Cost and Improve Efficiency*, OFF. OF ENERGY EFFICIENCY & RENEWABLE ENERGY (Feb. 5, 2018), https://www.energy.gov/eere/articles/platooning-trucks-cut-cost-and-improve-efficiency [https://perma.cc/7YAK-FLNM] (noting, in the context of military convoys, that "[u]sing platooning technologies in military applications could minimize the number of soldiers needed to man convoy vehicles, resulting in a reduced number of soldiers at risk of encountering roadside bombs").

An increase in the use of AVs may have significant impacts on the labor market. As noted above, dramatic changes in driving patterns will have comparably dramatic effects on those who drive for a living, including truck drivers, taxi and rideshare drivers, and chauffeurs.[138] Truck drivers soon may seem as quaint as elevator operators. The labor market will feel other ripple effects from the increased prevalence of autonomous cars and trucks. It is entirely possible that there will be a drop in the need for police officers, crossing guards, emergency medical technicians and ambulance drivers, emergency room physicians and staffers, sanitation workers, driving instructors, and auto-body workers and suppliers, not to mention employees at motor vehicle departments, insurance adjusters, civil court judges, and lawyers who handle auto-related tort claims.[139]

Roadside motels and short-haul airline flights could disappear, as passengers use AVs to transport them nonstop to destinations that are beyond today's acceptable driving distance and time.[140] AVs may themselves serves as roving hotels, not to mention sites for prostitution[141] and drug dealing.[142] Gas stations—likely transformed into recharging stations—may vanish or evolve into facilities resembling today's truck stops, with expanded shopping and shower facilities.[143] The mini-warehouse industry could witness a reduction in demand as people can suddenly store more of their belongings in a garage now freed of a privately-owned automobile.[144] Demand for guardrails may drop, as aggressive human drivers are replaced by AVs programmed to be more

138. *See supra* notes 41-45 and accompanying text.

139. What will people use for identification when no one needs or possesses a driver's license?

140. SCHWARTZ, *supra* note 1, at 114-15 (discussing potential changes in travel habits).

141. Scott A. Cohen & Debbie Hopkins, *Autonomous Vehicles and the Future of Urban Tourism*, 74 ANNALS OF TOURISM RES. 33, 40 (2019) ("'[H]otels-by-the-hour' are likely to be replaced by [autonomous vehicles], and this will have implications for urban tourism, as sex plays a central role in many tourism experiences . . . .").

142. *See* Jamie Lauren Keiles, *Full Tilt: When 100% of Cars Are Autonomous–Your Autonomous Dealer*, N.Y. TIMES (Nov. 8, 2017), https://www.nytimes.com/interactive/2017/11/08/magazine/tech-design-autonomous-future-cars-100-percent-augmented-reality-policing.html?emc=eta1 [https://perma.cc/BNL2-CBL6] ("The driverless vehicle eliminates small talk, supplying your fix directly from the glove box with a personalized passcode, à la Amazon Locker.").

143. SCHWARTZ, *supra* note 1, at 114-15 (discussing potential changes in travel habits).

144. *See* Peter Grant, *Driverless Cars Could Slam Brakes on Self-Storage Sector*, WALL ST. J. (Oct. 24, 2017, 3:55 PM), https://www.wsj.com/articles/driverless-cars-could-slam-brakes-on-self-storage-sector-1508874939 [https://perma.cc/U69B-PPLY] ("Because people will own fewer cars, they will have more storage spaces in their garages, so they won't need to rent it"); Colton Gardner, *Four Predictions about the Self-Storage Industry*, FORBES (Nov. 25, 2019, 7:00 AM), https://www.forbes.com/sites/theyec/2019/11/25/four-predictions-about-the-self-storage-industry/#77e480a78148 [https://perma.cc/96PW-3W3B] (paid post from founder of company that "help[s] people monetize their empty space").

docile.[145] Billboards might disappear, as travelers stop looking at the road.[146] Nearly all of these changes will cause net job losses.

Partially offsetting these potential job losses are gains related to the growth in the use of AVs. These new jobs include hardware and software developers, hardware installers, and tech support. Such jobs, of course, require specific types of technical knowledge, which means that displaced workers will need to be retrained for them. In addition, contractors and landscapers will fare well for many years as they repurpose former home garages and driveways.[147]

As previously noted, the expanded use of AVs may increase the total number of miles traveled by occupied vehicles and the total time occupants spend in vehicles.[148] This does not account for the additional miles that empty vehicles will travel, a previously unthinkable phenomenon.[149] Your own automobile may travel home unoccupied for the day and spend its resting time on the cheaper real estate of your own street instead of in a costlier downtown parking facility. This extra mileage could shorten vehicle lifespan and will also cause additional wear-and-tear on roads, bridges, and other public infrastructure.

This type of increased mileage may be offset by the efficiencies of autonomy, including the possibility of shared ownership or use. Instead of spending its time on your street, your vehicle may shuttle other family members around, reducing the number of vehicles owned by each household. Perhaps you will arrive at your job in a fleet-owned vehicle that makes several unrelated pickups and drop-offs during the day. Autonomous mass transit vehicles might introduce further savings.

Perhaps the largest question is whether autonomous vehicles will simply replace older, driver-operated vehicles on a one-for-one basis or whether all of us will be more amenable to a shared ownership model, perhaps taking the form of fleets that provide access to members as needed.[150] If current travelers opt out of vehicle ownership altogether,

145. *See*, SCHWARTZ, *supra* note 1, at 48 (describing some careers and roadway features that could become obsolete).

146. *See* DAVE BRAGG & STEPHEN PAZZANO, URBAN LAND INST. & GREEN STREET ADVISORS, THE TRANSPORTATION REVOLUTION: THE IMPACT OF RIDE-HAILING AND DRIVERLESS VEHICLES ON REAL ESTATE 16 (2017), http://s3-us-west-2.amazonaws.com/gstqa-us-west/uploads/2017/10/19153037/ULI-Green-Street-Fall-17-Presentation.pdf [https://perma.cc/T2D2-344F] ("Those riding in driverless vehicles will likely prioritize reading and entertainment over peering out the window.").

147. *See, e.g.,* Nesnow, *supra* note 78.

148. *See supra* Section II.A.3.

149. *See supra* notes 65-66, 71 and accompanying text.

150. Zipcar may prove to be an early demonstration of this model. *See How Zipcar Works*, ZIPCAR, https://www.zipcar.com/?&gclid=EAIaIQobChMInY34r7Gu5wIVxp6zCh0xJwcBEAAYASAAEgKPD_D_BwE [https://perma.cc/2SNS-QJZG] (last visited Oct. 10, 2020).

a single fleet car could replace several private vehicles.[151] The answer to this question has implications for traffic and road planning, parking or other vehicular storage, and total emissions released. Fleet ownership also reduces up-front costs for those who need transportation but lack the financial capacity to purchase their own vehicle.

Whole new categories of people will become mobile, including those who are too young to drive on their own, those who are old enough that they probably should not be driving any longer, and those with physical impairments that prevent or limit their driving.[152] Autonomous vehicles can have a revolutionary impact for these populations by removing some limitations on mobility, but this means that people who currently should not be alone in a vehicle—some of whom lack legal capacity—will become more ambulatory.[153] Will they have complete freedom of movement, including the ability to order a shared vehicle or to program an autonomous vehicle? Who will be the legally responsible party in the event of a mishap involving a nine-year-old on her way to soccer practice or a disabled senior heading home from physical therapy?[154]

Increased use of autonomous vehicles should eventually lead to sharp reductions in death, personal injury, and property damage.[155]

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151. *See* Jim Motavalli, *Who Will Own the Cars That Drive Themselves?*, N.Y. TIMES (May 29, 2020), https://www.nytimes.com/2020/05/29/business/ownership-autonomous-cars-coronavirus.html [https://perma.cc/A8B4-9S49] (discussing the likelihood of private ownership versus fleet ownership of vehicles and observing that passengers have become more reluctant to share vehicles since the COVID-19 pandemic began).

152. *Automated Vehicles for Safety*, NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., https://www.nhtsa.gov/technology-innovation/automated-vehicles [https://perma.cc/4Z9J-XZ92] [hereinafter NHTSA, *Automated Vehicles for Safety*] ("Today there are 49 million Americans over age 65 and 53 million people have some form of disability.").

153. *But cf.* Paula Span, *Older People Need Rides. Why Aren't They Using Uber and Lyft?*, N.Y. TIMES (Aug. 16, 2019), https://www.nytimes.com/2019/08/16/health/uber-lyft-elderly.html [https://perma.cc/9GDH-3CZH] (noting reluctance among some seniors to use ride hailing apps and observing, "Older adults, warned continually about scams and identity theft, fear that misusing an app could empty their bank accounts.").

154. *See* Leslie P. Francis, *Disability and Automation: The Promise of Cars that Automate Driving Functions*, 20 J. HEALTH CARE L. & POL'Y 229, 229-34 (2018) (arguing that AVs can be viewed as a type of mobility-assistance device for people with disabilities and regulated accordingly).

155. NAT'L HIGHWAY TRAFFIC SAFETY ADMIN., *supra* note 35 ("In the transportation sector, where 9 out of 10 serious roadway crashes occur due to human behavior, automated vehicle technologies possess the potential to save thousands of lives, as well as reduce congestion, enhance mobility, and improve productivity."). The impact of AVs may be even greater than that, given that many collisions are not reported. *See, e.g.*, Michael Laris & Ashley Halsey III, *Will Driverless Cars Really Save Millions of Lives? Lack of Data Makes it Hard to Know*, WASH. POST (Oct. 18, 2016), https://www.washingtonpost.com/local/trafficandcommuting/will-driverless-cars-really-save-millions-of-lives-lack-of-data-makes-it-hard-to-know/2016/10/18/6a678520-8435-11e6-92c2-14b64f3d453f_story.html?postshare=2071476886412270&tid=ss_mail [https://perma.cc/CT4Q-NXGQ] (noting that drivers underreport vehicular incidents by as much as 84 percent to avoid inconvenience and increases in insurance premiums, which means that any improvements brought about by the transition to AVs may be understated).

Autonomous vehicles, for instance, cannot drive while intoxicated.[156] While this will unquestionably be a huge benefit of the upcoming transportation revolution, it also raises new questions. If nearly all of the roughly 40,000 people who are killed in motor vehicle incidents every year instead survive,[157] and if many serious injuries are reduced or eliminated, it will have implications for everything from the health of the Social Security trust fund to actuarial planning for life insurance and long-term care insurance to individual planning for elder care. Even the organ-transplant industry is apprehensive, since it depends on organs harvested from otherwise healthy people who perish in collisions.[158]

Today's motor vehicles, typically Level 0 or Level 1, are enormously complex.[159] Software developers will need to be vigilant about hackers.[160] If large numbers of vehicles all employ an electronic guidance system, and if their movements are coordinated by a single traffic program, then malicious hackers can cause widespread damage.[161] Fleet vehicles are particularly vulnerable.[162] In fact, terrorists could potentially target fleet vehicles to use as weapons.[163]

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156. *See, e.g.*, Kieran Tranter, *The Challenges of Autonomous Motor Vehicles for Queensland Road and Criminal Laws*, 16 QUT L. REV. 59, 64-77 (2016), (describing how numerous roadway laws that are based on the presumption of human control over the vehicle, including laws regarding intoxication, may need to be modified in light of the growing presence of AVs).

157. *See supra* text accompanying note 20.

158. Speck, *Ten Rules*, *supra* note 70.

159. *See, e.g.*, SILBERG ET AL., *supra* note 10, at 2 (illustrating that a Ford F-150 has about five times as many lines of computer code as an F-35 fighter jet).

160. *See, e.g.*, Andy Greenberg, *Securing Driverless Cars From Hackers Is Hard. Ask the Ex-Uber Guy Who Protects Them*, WIRED (Apr. 12, 2017, 7:00 AM), https://www.wired.com/2017/04/ubers-former-top-hacker-securing-autonomous-cars-really-hard-problem/ [https://perma.cc/GNA6-VD3V] ("Two years ago, Charlie Miller and Chris Valasek pulled off a demonstration that shook the auto industry, remotely hacking a Jeep Cherokee via its internet connection to paralyze it on a highway.").

161. *See, e.g.*, Jamie Carter, *Hacked Driverless Cars Could Cause Collisions and Gridlock in Cities, Say Researchers*, FORBES (Mar. 5, 2019, 5:46 AM), https://www.forbes.com/sites/jamiecartereurope/2019/03/05/hacked-driverless-cars-could-cause-collisions-and-gridlock-in-cities-say-researchers/#5e26d80a2a09 [https://perma.cc/A82S-YZGZ] (noting that one expert "thinks that connected cars should use multiple networks to decrease the number of cars that could be compromised in any one hacking intrusion."). *But see* Peter Campbell, *Hackers Have Self-Driving Cars in their Headlights*, FIN. TIMES (Mar. 15, 2018), https://www.ft.com/content/6000981a-1e03-11e8-aaca-4574d7dabfb6 [https://perma.cc/PL6N-LDKW] (noting that another expert believes that "the safety of autonomous cars, which are designed to eliminate most of the million global road deaths a year, will far outweigh the dangers attached to human driving").

162. SILBERG ET AL., *supra* note 10, at 4 ("[S]ingular vehicle attacks may soon be a thing of the past. Fleetwide attacks—which will have a much more significant scope and impact and a much greater potential payoff for cyber attackers—threaten to disrupt not only automotive security but also many other aspects of the automotive business and operating model.").

163. *Id.* at 9 ("While there are many potential mass-attack scenarios, the worst of all might be the idea of a cyber criminal turning a whole fleet of cars into remote-controlled weapons of terrorism.").

Rather than disabling a single vehicle, a vandal can completely immobilize a city, perhaps causing injuries or deaths along the way.[164] Even less worrisome hacks need to be addressed. Developers are sure to come up with upgrades that provide drivers who purchase them with superior treatment, such as faster trips at their neighbors' expense. Of course, cities hoping to raise revenue might sell such upgrades, in effect creating a preferred class of speedier service for those willing and able to pay.

And there will be less roadkill! This has both desirable and undesirable consequences. On the one hand, it spares people, animals, and vehicles, which is unquestionably beneficial, and it will improve the survival rates of some endangered species.[165] At the same time, many non-human victims of vehicles are considered pests. For example, 1.5 million deer are killed in the United States each year by motor vehicles, including one killed by this author some years back. If most of these deer survive after human drivers disappear, they may outstrip the ability of their habitat to support them.[166]

III. HOW MIGHT GOVERNMENTS RESPOND?

It should be apparent from Part II that as the autonomous vehicle revolution progresses, governments will have to adapt to transportation patterns that will be changing rapidly, sometimes in unanticipated ways. Part III addresses each of the many potential changes that Part II raised. It examines the ways in which government bodies might modernize land use laws to keep pace with this technological and societal upheaval while also recognizing that land

164. *See* Greenberg, *supra* note 160 ("[S]olving autonomous vehicles' security nightmares will require far more open conversation and cooperation among companies."). *But see* Alex Hern, *Assume Self-Driving Cars are a Hacker's Dream? Think Again*, THE GUARDIAN (Aug. 30, 2017, 2:00 PM), https://www.theguardian.com/technology/2017/aug/30/self-driving-cars-hackers-security [https://perma.cc/K3HC-QAZ2] (suggesting that the complexity of the software in AVs may make them difficult to hack).

165. *See, e.g.*, Malia Wollan, *Full Tilt: When 100% of Cars Are Autonomous–The End of Roadkill*, N.Y. TIMES (Nov. 8, 2017), https://www.nytimes.com/interactive/2017/11/08/magazine/tech-design-autonomous-future-cars-100-percent-augmented-reality-policing.html?emc=eta1 [https://perma.cc/FEB6-9B9Y] (noting that an estimated one-fourth of the population of the endangered Florida panther was killed by motor vehicles during the previous year); *see also* Jason Bittel, *Pandemic Shutdowns Saved Thousands of Animals from Becoming Roadkill, Report Suggests*, WASH. POST (July 8, 2020 8:00 AM), https://www.washingtonpost.com/science/2020/07/08/coronavirus-shutdowns-saved-thousands-animals-becoming-roadkill-report-suggests/ [https://perma.cc/KT2D-A8RP] (examining the number of deer, bears, and other large mammals, but not smaller animals such as raccoons, killed in three states during stay-at-home orders and concluding "[i]f a similar drop occurred across the United States, where some estimates suggest as many as 1 billion wild animals are killed by vehicles each year, about 200 million creatures' lives would be spared annually").

166. Wollan, *supra* note 165 (predicting a population explosion among deer, raccoons, and opossums).

use laws are sticky and slow to adjust to innovation.[167] Many of these possible changes will require jurisdictions to re-examine, and become more flexible about, their comprehensive plans.[168]

A. Obvious Land Use Issues

1. Parking

Urban regulation of parking will need to be significantly modified as patterns of downtown street usage change. Many cities, particularly those that are heavily auto-dependent, mandate minimum numbers of parking space for downtown structures. Their reasoning seems to be that residents, workers, and shoppers in these cities travel largely in single-occupant vehicles and need someplace nearby to put their cars and trucks without strangling downtown traffic flow. The AV revolution will change these habits, and parking mandates will have to adapt accordingly.

Austin, Texas, provides a useful example. Section 25-3-83 of Austin's zoning code establishes fairly typical parking requirements for traditional neighborhood districts in a large city with a crowded urban core.[169] Commercial uses must provide one space for every 500 square feet of gross building area, dwelling units must provide one space for the first bedroom of a unit and one-half space for each additional bedroom, and townhouses, congregate living uses, educational facilities, and other uses must meet similar requirements.[170] The Code establishes parking design and construction standards.[171] It also addresses the location of parking lots and garages, the size of spaces, and off-street loading requirements.[172] Austin's Code has similar requirements for other types of neighborhoods.[173]

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167. *See, e.g.*, David Schleicher, *How Land Use Law Impedes Transportation Innovation*, *in* EVIDENCE AND INNOVATION IN HOUSING L. AND POL'Y 38, 54 (Lee Anne Fennell & Benjamin J. Keys, eds., 2017), https://www.cambridge.org/core/books/evidence-and-innovation-in-housing-law-and-policy/how-land-use-law-impedes-transportation-innovation/7808D78D60B2866B8B72A1AAA7504742/core-reader [https://perma.cc/DU3X-7LMB] ("[M]any people *like* our land use laws, so they are hard to dislodge."); *id.* at 40 ("'Today's urban and inner-ring suburban zoning politics will undercut future opportunities to restructure housing and retail. Innovations in transportation will increase the cost of our dysfunctional land use law regime.").

168. *See* APA, PREPARING COMMUNITIES, *supra* note 59, at 16 (recommending that "comprehensive plans should be less prescriptive and more goal oriented to help cities cope with and adapt to rapid changes.").

169. AUSTIN, TEX. LAND DEV. CODE § 25-3-83 [hereinafter, Austin Zoning Code].

170. *Id.* § 25-3-83(A)(6).

171. *Id.* § 25-3-84.

172. *Id.* § 25-3-83(A)(1)-(5).

173. *See generally id.* § 25-6, App. A - Tables of Off-Street Parking and Loading Requirements (establishing minimum off-street parking requirements for a wide range of uses, including commercial blood plasma centers, funeral services, and billiard parlors).

Requirements such as these were presumably drafted and then amended over time to reflect actual traffic patterns as they evolved, along with projected future needs. Cities adopted codes that they then modified as automobiles became more and more prevalent. There would have been little need to require one parking space per dwelling in the days when most households did not yet own a car, while today that number would be inadequate, with residents clogging streets searching for places to store their second and third vehicles. If patterns of vehicle ownership begin moving in the opposite direction and families start relying more heavily on vehicles they do not own and need not park, zoning codes will likely follow this trend. There will be no reason to require a number of parking spaces that vastly exceeds the number of vehicles that must be stored in a neighborhood. This trend will be particularly stark if, as AVs become prevalent, many citizens move to a vehicle-sharing model in which they own fewer cars and make greater use of shared, fleet-owned vehicles.[174]

It is also instructive to compare Austin's Code to the Zoning Resolution of the City of New York, a city in which relatively fewer residents own cars. Per capita car ownership in New York City has remained steady for several years at 0.22 cars per resident.[175] Nationwide, by contrast, the rate was 0.756 cars per resident in 2015, nearly three and one-half times that of New York City.[176] New York's zoning laws reflect this distinctive vehicle ownership pattern.

In the Manhattan Core, which is more densely packed than Austin's downtown, the New York Zoning Resolution actually establishes a parking maximum rather than a minimum for residences, presumably wanting as little valuable land as possible devoured by parking.[177] Moreover, those maximum numbers are quite low. In some Community Districts, "accessory off-street parking spaces may be provided for not more than 20 percent of the total number of new

174. The American Planning Association is advocating for a shared-ownership model. *See APA Policy Principles for Autonomous Vehicles*, AM. PLAN. ASS'N, https://planning-org-uploaded-media.s3.amazonaws.com/document/APA-Policy-Principles-Autonomous-Vehicles.pdf [https://perma.cc/CA4V-BLYS] (last visited Sept. 20, 2020) (Principle 1: "APA strongly encourages development of a shared mobility model instead of private ownership for AV travel . . . ."); *id.* (Principle 7: "APA supports efforts to share autonomous mobility as a service rather than encourage ownership of each vehicle individually such that universal mobility is brought closer to reality . . . .").

175. N.Y. CITY DEP'T OF TRANSP., NEW YORK CITY MOBILITY REPORT 14 (2016), http://www.nyc.gov/html/dot/downloads/pdf/mobility-report-2016-screen-optimized.pdf [https://perma.cc/XZ9Y-LX5P].

176. MICHAEL SIVAK, UNIV. MICH. SUSTAINABLE WORLDWIDE TRANSP., REPORT NO. SWT-2017-4, HAS MOTORIZATION IN THE U.S. PEAKED? PART 9: VEHICLE OWNERSHIP AND DISTANCE DRIVEN, 1984 TO 2015, at 2 (2017), http://www.umich.edu/~umtriswt/PDF/SWT-2017-4.pdf [https://perma.cc/2MEJ-7Q62].

177. N.Y.C. PLAN. COMMISSION, ZONING RES., art. I ch. 3 § 13-11, https://zr.planning.nyc.gov/article-i/chapter-3 [https://perma.cc/98AF-5PNU] [hereinafter, NYC Zoning Resolution]. Similar rules apply to non-residential uses. *See, e.g., id.* § 13-12 (applying maximums to uses such as hotels and retail).

dwelling units contained in the development."[178] In a city with far fewer vehicles per resident, the parking requirements are understandably much lower. But beyond that, New York's goal is to discourage parking, not to facilitate it.

If other cities see decreases in the number of owned vehicles per resident, it seems likely that they will begin to reduce their minimum parking requirements correspondingly. Developers that do not wish to construct costly parking will surely encourage this type of change. The only question is whether municipalities will wait even that long. Cities could decide to try to lead the trend and force the number of vehicles down by reducing parking requirements sooner and hoping that the number of vehicles then drops as a result. Their hope would be that frustrated—though perhaps more environmentally conscious—residents will begin to give up on vehicle ownership and move to mass transit, carpooling, bicycles, walking, or, ultimately, autonomous vehicles.[179]

If the number of cars stays the same, and even if it drops, those cars that remain will need to go somewhere when they are unoccupied. If these vehicles are owned by fleets, they may spend the day cruising, although even cruising cars experience downtime on nights, weekends, and holidays. In the alternative, AVs may spend their idle hours in parking lots on the periphery, which could lead some cities to encourage the growth of these facilities on the outskirts of town or even beyond their borders. Lots and garages may be zoned out of downtown and into less congested and less popular areas, perhaps near highways, railroad tracks, and other neighbors that are unlikely to object. This shift will also allow these municipalities to make more efficient use of downtown real estate while offsetting a portion of the parking revenue they will lose.

Changes in the location of parking will allow cities to re-use the downtown parcels that were previously dedicated to surface lots and garages, as well as the strips of roadway pavement presently dedicated to on-street parking.[180] Current zoning may already specify what uses

178. *Id.* § 13-11.

179. It is worth noting that the introduction of shared ride services such as UberPool only slightly offset the total increase in vehicle miles traveled attributable to the overall growth of transportation network companies. *See* SCHALLER, *supra* note 66, at 2 ("Shared ride services such as UberPOOL, Uber Express POOL and Lyft Shared Rides, while touted as reducing traffic, in fact add mileage to city streets," though slightly fewer miles than solo rides). In other words, carpooling is better than solo rides, but most of the people who decided to carpool were not solo riders but rather users of other forms of transit, including trains and buses. Thus, planners should not pin their hopes on carpooling.

180. *See, e.g.*, Ryan Ori, *Parking Lots Disappearing in Ride-Sharing Era as Downtown Construction Booms*, CHI. TRIB. (Mar. 23, 2018), https://www.chicagotribune.com/columns/ryan-ori/ct-biz-parking-redevelopment-ryan-ori-20180308-story.html [https://perma.cc/QUM4-5E3J] (comparing increasing value of downtown Chicago lots for residential purposes with decreasing value for parking due to the growth of ride-sharing and the decline in auto ownership).

are permitted. However, if a large amount of downtown real estate is suddenly liberated from parking uses, some jurisdictions may rethink their existing urban plans. Do they envision all of these former lots turned into more residences and retail? Will they want at least some additional land for green space, mass transit, or other purposes?[181] Might they have even newer ideas for these suddenly open spaces, some of which will be large, contiguous, and entirely vacant? Land assemblages in downtown districts are often difficult to accomplish, but large vacant lots may soon fall into the laps of many city councils or private owners. Each jurisdiction will need to update its comprehensive plan and its zoning code to reflect whatever it decides as to the repurposing of this land.

2. Building Entrances and Drop-Off Areas

People who used to drive their own vehicles will still need to get to work somehow. They may travel on foot, by bicycle, or by public transportation, in which case they will arrive at their workplace and likely enter through the front door, just as most guests do. Alternatively, they may travel to work in their personal AV, a fleet-owned AV, or a taxi or rideshare, perhaps now self-driving, which means that they must disembark from a vehicle somewhere close to their destination. As the number of AVs rises, buildings will see more of their occupants dropped in front of their workplaces by vehicles that then continue onward. Those vehicles will need a place to discharge their passengers and then to retrieve them later in the day, suggesting that buildings will need to offer more space than they currently provide for drop zones near their entrances. Zoning and building codes already address matters such as driveways and curb cuts, and the massive changes in travel patterns that AVs will cause should lead jurisdictions to modify these provisions accordingly and add new ones.[182]

This change is, in many ways, the mirror-image of the modifications just discussed regarding parking requirements. If we assume that the same number of people work downtown—and the number might actually increase or decrease—every person who no longer drives herself in her own car is arriving some other way. Some of those

181. New York City has narrowed some of its major thoroughfares, including Broadway, and created bicycle lanes, pedestrian plazas, and seating areas from the newly available space. *See, e.g.*, Winnie Hu, *Major Traffic Experiment in N.Y.C.: Cars All but Banned on Major Street*, N.Y. TIMES (Aug. 8, 2019), https://www.nytimes.com/2019/08/08/nyregion/14th-street-busway.html [https://perma.cc/BTX6-BMBT] (discussing recent closing of 14th Street to vehicular traffic).

182. *See, e.g.*, NACTO, BLUEPRINT, *supra* note 18, at 116 ("Enhanced with sensors, the price and allowed use for the most in-demand curb space could fluctuate according to the time of day or shifting public priorities. Real-time curbside management systems could allow vehicles to automatically reserve time slots a few minutes in advance of arrival at a site. Armed with sufficient data, cities could actively manage curbsides, setting rates in real-time, changing uses with demand, and automating enforcement to ensure turnover.").

alternatives, including AVs, require that a vehicle drop its passenger outside a building to which that passenger used to drive herself. As the need for parking falls, the need for space to discharge passengers will rise.

Office buildings serviced by AVs will display many of the attributes of today's elementary schools, as noted above, with a large cohort of building occupants dropped off at roughly the same time in the morning and then picked up in the afternoon and early evening.[183] For this reason, just as urbanized areas will have to modify their parking regulations, they will also have to amend their codes to expand pickup and drop-off areas in commercial districts. Airports and hotels, which already have experience with large numbers of vehicles that stop, drop, and go, are hardly models of efficiency, and airports have struggled to manage the huge increase in pickups and drop-offs since the introduction of ride-sharing services.[184] Worse still, office workers are more likely than travelers to arrive at their destination and then leave later in the day in large groups at about the same time. Thus, businesses and governments may have to experiment with staggered work schedules and other new initiatives as they strive to develop more efficient systems.

Cities will have to amend their zoning and building codes to address matters such as curb cuts and driveways and will need to update traffic laws regarding stopping and standing.[185] The net effect of the evolution in parking and pickup conventions should be to free up some currently occupied downtown space for other uses. However, the overall efficiency gains from parking areas that are no longer necessary will be offset at least in part by the need to expand passenger drop zones.

3. Vehicle Miles Traveled

As noted above, it is difficult to predict whether the total number of miles traveled by all vehicles will increase or decrease.[186] Transportation will become more efficient, as vehicles can predict accurately what other vehicles are going to do. Choke points will become less choked, vehicles will avoid traffic by rapidly finding less congested alternate routes, and traffic may spread out more evenly throughout the day. For these reasons, vehicle-miles traveled may remain the same or decrease, and vehicle time on the road will likely decrease, all other things staying equal.[187]

183. *See supra* note 64 and accompanying text.

184. *See supra* notes 51, 71.

185. *See* NACTO, BLUEPRINT, *supra* note 18, at 116-17 (discussing different priorities for the use of the curb).

186. *See supra* Section II.A.3.

187. *See supra* Section II.A.3.

All other things will not stay equal, however. Vehicles that travel their routes more efficiently can cover more mileage in the same amount of time, which means that drivers accustomed to a twenty-minute trip may be willing to cover longer distances in the same amount of time rather than saving a few minutes. Moreover, driving time will be usable for other purposes, so commuters may be happy to brave longer commutes: They can still have their suburban house on a large lot without losing two hours per day to driving, because that travel time can be used for something more productive.[188]

In addition, AVs, unlike their more traditional predecessors, will sometimes be transporting themselves around unoccupied, readying themselves for their next occupant. It is possible that even if the number of vehicles drops and those vehicles and their driving patterns become more efficient, the total number of miles traveled by all vehicles will increase. Some of those vehicles may be empty, but they will still clog roads and consume energy.[189]

This potential increase in the overall time and distance that vehicles spend on the road will have a number of long-term impacts on urban land use patterns and governance. It will have obvious environmental effects, since vehicle emissions are a function of time and distance traveled. These negative impacts will be balanced by the fact that autonomous vehicles operate more efficiently in the ways just noted, plus the fact that these vehicles are likely to be powered by electricity rather than fossil fuels.[190] It is difficult to predict which factor will outweigh the other, but it is important to note that the overall environmental effects of the AV transformation will not necessarily be beneficial. This may lead governments at all levels to expand environmental protection laws, although it hardly bears mentioning how politicized all decisions involving the health of the environment have become.

188. *See supra* notes 71-75 and accompanying text.

189. *See supra* notes 65-66, 71 and accompanying text.

190. Electricity, while greener than fossil fuels, is not pollution-free either. *Alternative Fuels Data Center: Emissions from Hybrid and Plug-In Electric Vehicles*, U.S. DEPT. OF ENERGY: ENERGY EFFICIENCY & RENEWABLE ENERGY, https://afdc.energy.gov/vehicles/electric_emissions.html [https://perma.cc/GJR3-28P9] (last visited Dec. 28, 2020) ("In the case of gasoline, emissions are produced while extracting petroleum from the earth, refining it, distributing the fuel to stations, and burning it in vehicles. In the case of electricity, most electric power plants produce emissions, and there are additional emissions associated with the extraction, processing, and distribution of the primary energy sources they use for electricity production."). A dramatic expansion in the popularity of electric vehicles raises the question of whether the existing power grid can support the increased demand. *See* APA, PREPARING COMMUNITIES, *supra* note 59, at 6 ("[A]ssuming that future AVs will largely (if not entirely) be electric vehicles, where and when will they charge, and how will this impact the power grid?").

Increases in vehicle efficiency, enhancements to routing effectiveness, and changes in travel distance and time will have other impacts. In addition to the parking fees already discussed,[191] other sources of government revenue arise from vehicles, some of which are tied to the number of vehicle miles traveled. These include highway tolls and gasoline taxes, which disproportionately affect trucks. Toll collections may increase, although vehicles will be able to find alternate routes and quickly calculate the precise value of the time savings brought about by traveling on a toll road rather than a free alternative. Fees assessed on transportation network companies might also increase.[192] Gas taxes collected will increase with miles traveled, although, once again, these increases will be offset considerably by the ongoing transition to hybrid and electric vehicles, which use less or no gasoline.[193] State and local governments that rely on gasoline tax proceeds for budget items such as roadway construction and maintenance will need to find alternatives.

Other revenue sources, less closely tied to mileage, will shrink or disappear. Traffic violations should become a thing of the past, and the next generation of travelers will view traffic tickets the way today's twenty-somethings view dial telephones. The reviled tire boot will become a distant memory, thankfully. Revenues from parking will be reconfigured.[194] Airport parking fees will dry up, replaced perhaps by drop fees.[195] Proceeds from commuter parking will contract and be reallocated to remote locations, possibly in other jurisdictions, and will be partially offset by new drop fees.[196] One group of scholars has suggested imposing a "geometry tax" based on the amount of physical space a person on the streets is occupying.[197]

State and local governments that wish to hold themselves harmless against these sharp drops in revenue, or perhaps even benefit from these changes, will have to find alternative steady revenue sources.

191. *See supra* notes 122-24 and accompanying text.

192. *See* Colin Campbell, *No You Don't Have To Pay Me Back, It's Just $2.1 Million*, GOVERNING (Jan. 23, 2020), https://www.governing.com/finance/No-You-Dont-Have-To-Pay-Me-Back-Its-Just-2-Million.html [https://perma.cc/FVD7-JLFE] (noting that Baltimore lost $4.1 million due to reduced revenue from the city's parking tax, parking meters, and city-owned garages, which would have been partially replaced by $2.1 million in taxes on transportation network rideshares that were authorized but never implemented).

193. *See* CHRIS HARTO & SHANNON BAKER-BRANSTETTER, RISING TREND OF PUNITIVE FEES ON ELECTRIC VEHICLES WON'T DENT STATE HIGHWAY FUNDING SHORTFALLS BUT WILL HURT CONSUMERS 2 (2019), https://advocacy.consumerreports.org/press_release/evfees/ [https://perma.cc/Z6KN-3LHM] ("Existing and proposed EV [electric vehicle] fees in 26 states are up to 3x higher than the annual gas tax would be for the average new car in 2025.").

194. *See, e.g.*, CLARK, *supra* note 52, at 14 (suggesting that as demand for airport garages drops, they can be repurposed for AV storage).

195. *See supra* notes 51, 71.

196. *See supra* notes 47-48 and accompanying text.

197. CLARK, *supra* note 52, at 19 (suggesting that this approach will discourage roving by empty vehicles while encouraging carpooling and vehicle sharing).

One obvious option is a per-mile fee for the use of public roadways.[198] The current electronic system of collecting tolls, exemplified in seventeen states by E-ZPass, can be expanded to all public roadways.[199] In fact, jurisdictions such as New York City that are moving to congestion pricing may well end up collecting their new charges in this manner.[200] As all vehicles become smarter, it will become relatively simple to calculate actual miles traveled directly from odometer readings, GPS data, or monitoring of onboard computer systems. Alternatively, if fleets replace privately owned vehicles, whether they are autonomous or not, jurisdictions can simply assess a direct tax on the charge to passengers, which is already calculated based on time and distance. These methods reduce the traveler's privacy, but this information is already being collected and used for other purposes by public entities, manufacturers, and insurers.[201]

Modifications in transportation will also create new opportunities for generating revenue. As already discussed, governments may begin charging drop-off and pickup fees, as some airports have already started to do for rideshare drivers.[202] This approach could be expanded to cover drop-offs and pickups on public roadways.[203] To the extent that AVs are still privately owned, rather than operated by fleets that keep them cruising on the road, parking fees received at remote locations will replace at least some of the revenues lost from downtown parking.[204] Changes in technology are likely to lead to new opportunities for producing revenue that today's government officials cannot even foresee.

Governments can also experiment with increasing mileage fees at peak times, expanding the congestion pricing model to encourage vehicles to take to the roads when they are less crowded.[205] This will allow those who are willing and able to pay more for convenience to do

198. Gasoline surcharges, unlike fees calculated on a per-mile basis, reward more efficient vehicles and may induce drivers to replace older gas-guzzlers with newer vehicles. Per-mile fees simply discourage driving.

199. *See generally About Us: Members*, E-ZPASS GROUP, https://www.e-zpassiag.com/about-us/members [https://perma.cc/ZVJ2-AZL] (last visited Sept. 21, 2020).

200. Bruce Schaller, *New York City's Congestion Pricing Experience and Implications for Road Pricing Acceptance in the United States*, 17 TRANSP. POL'Y 266, 267 (2010) ("Under the Mayor's plan, congestion fees could be paid using the established E-ZPass electronic tolling system, or through cash and credit card payment channels at retail stores, telephone and web-based systems.").

201. *See supra* note 19.

202. *See supra* notes 51, 71.

203. *See supra* notes 51, 71.

204. In addition, because these vehicles are unoccupied when they arrive at and later depart from the parking facility, they can park more closely together. No vehicle operator needs to be able to open the door or access the trunk, which increases parking density and the revenue that results. *See* SCHWARTZ, *supra* note 1, at 59 (noting this phenomenon).

205. *See* NACTO, BLUEPRINT, *supra* note 18, at 59-67 (describing why congestion pricing is needed and explaining how cities can build support for it).

so, while providing cost-saving opportunities for those who want or need them.[206] This approach may discourage some driving while shifting other traffic to off-peak times or to mass transit.[207] Increasing the efficiency of street usage may also prevent or defer the need to spend money to expand overtaxed roadways.[208]

4. "Road Diets"

Autonomous vehicles are better than human drivers at communicating to other vehicles what they plan to do and at knowing what other vehicles will do. Because of the ongoing rapid intercommunication among AVs, they can drive closer to their neighbors, both side-to-side and front-to-back. Vehicles that sway and waver less can operate in narrower lanes. Vehicles that know immediately when their neighbors will accelerate or brake can follow each other more closely. As a result, the same number of vehicles will need less roadway space.[209] Crowded cities today must decide when to build new roads and widen existing ones. The AV revolution should reverse this trend, and jurisdictions may be able to narrow existing roadways and find new uses for the paved space that is suddenly liberated.

Going forward, jurisdictions will face new challenges. Rules regarding roadway engineering and construction will have to evolve. If large groups of passengers share vehicles that are owned by a fleet, it is likely that some of those vehicles will be smaller and lighter. After all, a family that currently owns a large SUV needs all that room only when the whole family is traveling together, and a parent who commutes alone can make that trip in a much smaller vehicle. Thus, the mix of vehicles on the road may change, which could require a rethinking of how roadways are designed. Autonomous vehicles are less likely to accelerate rapidly and jam on the brakes without warning, which will reduce wear-and-tear on both the vehicles and the roads they travel.[210] And the combination of skinnier lanes and reduced on-street parking will free up long, skinny strips of land that are currently occupied by moving or parked vehicles for other uses.

206. *Id.* at 64.

207. *Id.* at 60-61.

208. *Id.* (describing three possible models: charging for use of a particular congested zone, charging for the use of the curb, and charging by the ride or by trip distance); *see also* Scott Beyer, *What's a City's Curb Space Worth?*, GOVERNING (Nov. 2, 2020), https://www.governing.com/community/Whats-a-Citys-Curb-Space-Worth.html [https://perma.cc/46CJ-HQKH] ("Curb space should be charged for, using technology that can calculate a curb's current occupancy rate, its latent demand and what its market price should be. This would help prevent overcrowding and suboptimal curb use, and, like road pricing, attack the skewed status quo in U.S. cities, where car use is underpriced.").

209. *See supra* Section II.A.4.

210. *See supra* note 32.

Jurisdictions will have to reassess their approach to urban design and planning more broadly if roads suddenly become thinner. Those newly available strips of pavement can be used for a variety of purposes but will need to be used in a consistent manner. A city might add a bicycle lane, widen its sidewalks, or expand retail and dining areas onto these strips of land, but it cannot effectively choose each of these three options on three contiguous blocks. Governments will have to reconsider how they want their downtowns to look and function, and they may have to do so on fairly short notice, with interest groups lobbying passionately for incompatible projects. They may opt for greater emphasis on pedestrians, bicyclists, and green space rather than retaining the current preference for motor vehicles. Even simple amendments to zoning codes can be controversial though, and such comprehensive changes to the urban landscape will be the subject of much heated local debate.

5. Vehicle Sharing and Mass Transit

One of the most significant unknowns in the transformation to AVs is the extent to which it will change patterns of vehicle ownership. At one extreme, travelers may simply engage in a one-for-one swap, replacing each of their conventional cars with an autonomous vehicle over time. If this happens, the number of vehicles and vehicle-miles traveled is likely to increase. Some people who did not own traditional vehicles, such as people with disabilities and older drivers who have given up their vehicles, may decide that autonomous vehicles are the solution to their mobility problems.[211] If this happens, the transition may prove to be from one vehicle to one-plus, increasing the total number. Since people who used to travel together, such as a parent and their child or an adult with an elderly parent, may now travel in separate vehicles, the total mileage traveled could easily increase as well.[212] From the perspective of traffic planning and reduction of adverse environmental side effects, this is the poorest solution, resulting in more vehicles on the road more of the time and more total transportation miles.

At the other extreme, large numbers of current owners may decide that it is cheaper and more efficient to share their vehicles once those vehicles are autonomous. I cannot carpool with my neighbor if she begins and ends work an hour later than I do, but we can easily share

211. Many Americans fall into one or both of these categories. *See* NHTSA, *Automated Vehicles for Safety*, *supra* note 152.

212. This is not necessarily the case. A vehicle that takes a child to soccer practice, waits nearby, and then drives her home covers fewer miles than a parent who makes two complete round trips from home, even though one person is traveling rather than two. It also saves the parent considerable time. Conversely, that parent might previously have "bunched" errands into a single excursion rather than making separate AV trips for each one. It is difficult to predict how people's daily travel patterns will change as they figure out the best uses for AVs.

a fleet-owned autonomous vehicle, since we will not be using it at the same time. Fleet ownership may become the prevalent model, with large numbers of users signing up for services that provides shared vehicles promptly when summoned. In effect, the Uber model, minus the drivers, would dominate, which most likely has always been Uber's long-term plan.[213] Under this second model, the total number of vehicles on the road should drop, and each vehicle will be used more efficiently rather than sitting empty for most of the day.[214] Those vehicles will not last as long, since they will be deployed more like taxis, but fewer of them will be on the road at any one time.[215]

Any gains that result, however, may be offset by an increase in the total number of vehicle-miles traveled. The fleet car that I share with my neighbor not only must take each of us to and from work, it also must cruise to and from each of those four trips empty in between passengers. Our two privately-owned vehicles, by contrast, covered fewer miles, though each had to spend the day sitting near our respective offices. Had we carpooled, a single vehicle would have covered even fewer miles. The end result of fleet ownership might be fewer vehicles on the road but more overall miles driven than before.

An UberPool model would be more efficient than single-occupant fleet cars, gathering travelers who are traversing similar routes into one vehicle.[216] This paradigm, however, requires each occupant to give up some convenience and speed, as the vehicle zig-zags to pick up and drop off its various passengers along the way. Some riders may willingly accept this inconvenience at the right price, while others may value their time more than the cost savings. This model represents somewhat of a midpoint between traveling alone and using mass transit, in terms of both convenience and cost.

To the extent autonomous vehicles pull riders from buses and subways, the effect on traffic, and thus on the environment, could be devastating. Mass transit is extremely cost-effective and condenses large groups of travelers into small areas of road or underground

213.

> [I]nvestors value ride-hailing companies that lose money many times more highly than automakers who still do eke out a profit. But, those investors have also learned why ride-hailing companies are unprofitable: human drivers expect to be paid in real money. So, whether we want robot cars or not, the leaders at Uber, Lyft, Ford, and GM and the rest don't just want them. They need them.

ALBERT, *supra* note 77, at 256.

214. Fox, *Influence*, *supra* note 41, at 11.

215. *See id.* at 11-12 (comparing vehicle miles traveled and vehicular life span for private automobiles and taxis).

216. *UberPool: Together We Save*, UBER, https://www.uber.com/us/en/ride/uberpool/ [https://perma.cc/MM5G-2R22] (last visited Sept. 21, 2021).

space.[217] It takes longer to travel by mass transit, since the traveler most likely has to walk to a pickup location and then from a drop-off site to his final destination. And the vehicle itself likely travels slowly and makes numerous stops along the way. This inconvenience is usually offset by the individual benefit of lower cost and the societal benefit of reduced externalities such as traffic and greenhouse gas emissions.

Travelers who have access to mass transit constantly must calculate whether these benefits merit the increased bother. To the extent that AVs provide an additional option that is expedient and relatively inexpensive, that may be enough to tip the scales for some travelers, tugging them off the subway and into a smaller, quicker vehicle. If the AV revolution accentuates this trend, the increased number of lightly occupied vehicles could overwhelm streets and increase harm to the environment.

How should governments respond to these challenges and uncertainties? A government's main concern is to move people where they want to go in a convenient, efficient, inexpensive manner without destroying the local environment or overburdening road capacity. The government may decide that it is worth taking a loss on a transit system—subsidizing it with other taxpayer dollars—to reduce overall traffic. Investments in mass transit can involve huge cost outlays, made in the hope that, over time, ridership will cover some of the expense and the subsidies necessary to fill any remaining gap will prove to be a worthwhile investment.[218]

If AVs attract passengers who used to travel on buses and trains, then user fees will drop, the government subsidy will have to increase accordingly, and the traffic and pollution problems the government was trying to reduce will begin to swell again. For governments that are contemplating future infrastructure investments, the potential growth in AVs and the inability to predict just how much they will impact mass transit ridership add further uncertainty to the

217. For an incredibly effective graphic demonstrating how much less road space a bus or a light-rail train occupies than private automobiles transporting the same number of commuters, see Speck, *Ten Rules*, *supra* note 70 (shown at "5 - Understand transit geometry").

218. It is important not to overlook the extent to which governments presently subsidize travel in private vehicles. *See, e.g.*, Shill, *supra* note 54 (noting how governments create incentives for private automobile use through tax, environmental, insurance, tort, vehicle safety, and criminal laws); Stevie Olson et al., *The $64 Billion Massachusetts Vehicle Economy* 3 (Harv. Kennedy Sch., Working Paper No. RWP19-038, 2019), https://www.hks.harvard.edu/publications/64-billion-massachusetts-vehicle-economy [https://perma.cc/J78G-CGM6] (concluding that the vehicle economy of Massachusetts costs $64.1 billion per year, more than half of which is borne by the public, and noting that this amounts to $14,000 per family, including families that do not own cars).

calculation of whether to spend more money.[219] Of course, the same uncertainty applies to the huge investments in AV infrastructure that the new technology will necessitate.[220]

In short, it is difficult to foresee whether AVs will be owned individually or in fleets, and it is difficult to know the extent to which the growth in the number of AVs will affect ridership on public transit. Governments that are deciding whether to support and expand existing mass transit systems and whether to construct new ones may not be able to wait. They need to predict ridership levels many years into the future. These forecasts are far more perilous during times of revolutionary change such as the one we are entering. It is easy to envision a huge drop in the number of travelers who use mass transit systems, particularly daily commuters, but it is also plausible that ridership will remain stable or even increase. It is a huge challenge for governments to know what to do when so many of the assumptions they must make are based on uncertain future facts. Given the enormous cost of infrastructure investments, governments may be understandably hesitant to invest further in mass transit until they have a clearer sense of how the AV revolution will play out.

Governments can certainly place a finger on the scale, as New York City recently did when it capped the number of ride-sharing drivers it will allow.[221] By limiting supply, this approach controls traffic by ensuring that no new rideshare drivers will be on the roads. This approach also should increase the price of shared rides, which may persuade some people to switch back to subways and buses, or never to abandon them in the first place.[222]

Efforts of this type can interfere with developing markets in unpredictable ways. Politicians may reconsider decisions such as these under pressure from constituents and in the face of intense lobbying

219. *See, e.g.*, Badger, *supra* note 92 ("'Don't build a light rail system now. Please, please, please, please don't,' said Frank Chen, a partner with the venture capital firm Andreessen Horowitz.").

220. McCormick, *supra* note 88, at 21 ("When the Model T was introduced, . . . no one could have predicted that we would have 41,000 miles of interstate highways across the United States decades later. It's just as difficult to predict the impact of AVs.").

221. Emma G. Fitzsimmons, *Uber Hit with Caps as New York City Takes Lead in Crackdown*, N.Y. TIMES (Aug. 8, 2018), https://www.nytimes.com/2018/08/08/nyregion/uber-vote-city-council-cap.html [https://perma.cc/6P56-WY5X] ("New York became the first major American city on Wednesday to halt new vehicle licenses for ride-hail services, dealing a significant setback to Uber in its largest market in the United States.").

222. *See* Eric Phillips, *The Future of Autonomous Vehicles in American Cities*, 21 N.Y.U. J. LEGIS. & PUB. POL'Y 287, 291 (2018) ("By making car users internalize . . . costs, policymakers can encourage a future in which more residents choose to forgo personal car ownership in favor of shared vehicles, but also one in which vehicle usage is not over-incentivized relative to transit modes that carry fewer negative externalities, such as public transit.").

from the industries being regulated.[223] Disgruntled former subway riders who are unwillingly forced to return to their old method of transportation may well complain to their elected officials or support opponents who promise to reverse the change. New York must compete for business with other cities, raising the question of whether companies will choose to locate in places where their workers' transportation options are more limited.[224]

B. Less Obvious Land Use Issues

The less obvious issues described earlier are second-order matters that will arise after first-order consequences of the AV revolution play out.[225] Once jurisdictions address the fact that there is less need for parking downtown, they can try to figure out what to do with parking structures that are no longer being used. Once they confirm that more vehicles truly can fit in less roadway space, they can decide what to do with the land that is newly available.

If it is difficult for local government officials to predict the future and address first-order problems, second-order problems are even more hypothetical. There are more chances for the future to play out differently than anticipated, which means that local government officials will be guessing even more when they try to forecast today how to react to these more remote changes. As a result, this Section must go even further out on a limb in suggesting how governments might respond to an uncertain future and will therefore devote less space to these second-tier issues. My goal here is to highlight some more distant topics that seem likely to arise but that governments might view as too premature to tackle yet.

The previous Part has already proposed answers to three questions, namely how governments should repurpose older facilities such as parking garages that have become obsolete,[226] how to engineer and re-engineer skinnier and more efficient roadways,[227] and how to confront the likely reduction in municipal revenues derived from current transportation methods.[228] With regard to three other issues—

223. *See, e.g.*, Yihyun Jeong, *Fate of Scooters in Nashville to be Considered by Metro Council*, TENNESSEEAN (July 1, 2019, 4:02 PM), https://www.tennessean.com/story/news/2019/07/01/lime-scooter-nashville-rental-metro-council-decision/1617755001/ [https://perma.cc/X7V3-WENA] (describing dispute over terms by which scooter operators may conduct business in Nashville).

224. *See, e.g.*, *Amazon HQ2 RFP*, AMAZON 2, https://assets.documentcloud.org/documents/4378750/Amazon-HQ2-RFP.pdf [https://perma.cc/YB6L-3VE4] (last visited Sept. 21, 2020) ("The following is a summary of the Project's ideal site and building requirements: . . . Close to major arterial roads to provide optimal access . . . Direct access to rail, train, subway/metro, bus routes.").

225. *See supra* Section II.B.

226. *See supra* Sections III.A.1-2.

227. *See supra* Section III.A.4.

228. *See supra* Section III.A.5.

the installation of the hardware necessary for AVs to operate, cooperation among jurisdictions to ensure compatibility of standards, and the removal of traffic signals and stop signs—it is evident that jurisdictions will have to make huge bets on new technology and hope that they do not guess wrong.[229] Automobile manufacturers, hardware manufacturers, software developers, telecommunications companies, and new market entrants will all come up with forward-looking ideas about how the future of transportation should look. Some of these ideas will prevail in this competitive market, but others will prove to be dead ends.

Each of these companies will want to survive and become or remain a market leader once AVs supplant traditional vehicles. Many of their ideas will be viable and practical, but it is unlikely all of them will be adopted, and some of them are likely to be irreconcilable with one another. Twenty or thirty years from now, it may seem inevitable that the prevalent system was going to emerge victorious all along, just as it seems difficult today to imagine the world without Microsoft and Apple and the technology standards associated with them. But it was not predetermined in the 1970s that these companies and their paradigms would conquer technology markets. Apple struggled for many years before its subsequent vigorous rebound.[230] While a similar process is unfolding among developers of AVs and associated products, jurisdictions will be making large wagers on technology and standards that may turn out to be unworkable, undesirable, or simply less popular than others.

When considering what new technology standards to adopt for the operation of AVs within their borders, jurisdictions can do little more than pay attention to recent developments, work with various companies within this rapidly growing industry, and make educated decisions about how best to proceed, perhaps in cooperation with their sister jurisdictions. It seems likely that at some point one of two things will happen. It is possible that one standard will become the obvious market leader and emerge dominant. If, for example, Google develops software that is far superior to that of any of its competitors and large numbers of users start to adopt this standard, that may lead to a snowball effect in which Google eventually becomes the sole national standard for the operation of AVs. Each jurisdiction will survey the market, observe what is happening, and elect to jump aboard.

Alternatively, no leader may emerge, and a group of competitors could adopt different standards that eventually will have to become compatible with one another.[231] The Microsoft Office suite of products

229. *See supra* Section II.B.3 and note 110 (comparing V2V and V2I technology).

230. WALTER ISAACSON, STEVE JOBS 186-210 (2011).

231. *Cf.* Vanessa Swales, *Have an Extra Hour? Try Passing Through the 'Daylight Savings Donut',* N.Y. TIMES (Nov. 4, 2019), https://www.nytimes.com/2019/11/02/us/daylight-

originally functioned only on computers that ran Microsoft Windows, as Microsoft and Apple fought to dominate this market, just as VHS earlier defeated Beta to control the videocassette market. Fortunately, Microsoft later developed versions of its software that run smoothly on Apple computers, ending a product war that could have proved detrimental to both companies, not to mention their billions of users. Mobile phones on the Verizon network can similarly connect to mobile phones on the Sprint network. It seems unlikely that a car that functions smoothly on New York's Apple-based system will die halfway across the George Washington Bridge just as it passes into New Jersey's Google-based system, or that Honda AVs will operate perfectly on one side of State Street in Bristol, Tennessee, but will be unable to make the return trip on the other side of State Street in Bristol, Virginia.[232]

Once jurisdictions agree on a single standard or a set of mutually compatible standards, or once the federal government makes the selection for them, the issue of traffic signals, stop signs, and lane striping will become easier to resolve.[233] It is difficult to predict what that resolution will be without knowing the features of the AV hardware and software systems that prevail. Either signals, signs, and broken white lines will become a thing of the past, visible only in old movies, or they will remain. They might persist to aid pedestrians, cyclists, and any traditional vehicles that remain on the road. Or they might endure as security blankets for transition-era humans who feel uncomfortable passing through an intersection without seeing that the light is green, even though their vehicle already knows it is safe to proceed. Steering wheels may survive for similar reasons.

The physical placement of the hardware AVs need will be more problematic. Jurisdictions may not hold rights-of-way that are satisfactory for this purpose.[234] For example, if a sensor needs to be set back at least fifteen feet from the roadway to have a wide enough field of vision, it is possible that it will need to be placed outside of the current roadway right-of-way. Even if the equipment can be placed

saving-time-doughnut.html [https://perma.cc/DV9H-HD4J] (describing the confusing incompatibility of time zones between the Navajo and Hopi reservations in Arizona).

232. NHTSA, ACCELERATING, *supra* note 9, at 7 ("Today, a motorist can drive across state lines without a worry more complicated than, 'did the speed limit change?' The integration of HAVs [highly automated vehicles] should not change that ability.").

233. The federal government has been slow to adopt national standards for autonomous vehicles more generally, in part due to political disagreements and in part due to a lack of Congressional focus. *See* Maggie Miller, *Action on Driverless Cars Hits Speed Bump as Congress Focuses on Pandemic*, THE HILL (May 20, 2020), https://thehill.com/policy/technology/498863-action-on-driverless-cars-hits-speed-bump-as-congress-focuses-on-pandemic [https://perma.cc/ZQQ3-F9ZZ] (describing the failure of Congress to adopt legislation in 2018 after two years of work and noting that "the lack of federal action opens the door to complicated state-by-state regulations and raises the prospect that the United States will lose the international race to launch self-driving cars").

234. *See supra* notes 114-17 and accompanying text.

within an existing easement, each jurisdiction will have to confirm that the right-of-way permits that use.[235] Years of litigation ensued when telecommunications companies began placing their cables on railroad rights-of-way, some of which had been obtained for railroad purposes only and thus did not permit this expansion of the dominant estate.[236]

Placement of AV equipment will also have to comply, in some cases, with restrictions established by homeowners' associations ("HOAs"). If HOA covenants prohibit the placement of necessary equipment on the exterior of a building, any such placement will require amendment of the restrictions, a task that is often difficult or impossible to accomplish.[237] Alternatively, the federal government may need to step in, just as it did with regard to the placement of satellite dishes on residential property.[238] HOA declarations have fallen behind the times on subjects including smoking restrictions, pet ownership, and placement of clotheslines, and the installation of AV hardware may prove no different.[239]

Jurisdictions may determine that they have to pay enormous sums of money to acquire easements and to persuade HOAs to modify their covenants. This will drive up the cost of the AV infrastructure, a cost increase that will likely be passed through the system and borne by the ultimate user. This may be a fair outcome since the AV user is making use of someone else's property, but it will increase the cost of establishing and maintaining the AV infrastructure.

The possible expansion of vehicle platooning, particularly for trucks, raises the question of how best to design and use our interstate highway system. A lead truck may conduct ten or more trailing trucks that are close enough together that they function as one very long vehicle.[240] A platoon transforms a group of individual trucks into an assemblage that more closely resembles a train on an interstate highway system that was not designed for vehicles of such great length. When they enter the road, truck platoons need an extended opening in traffic to merge onto the main roadway, and platoons are difficult to pass. Thus, they will impair the operation and safety of

235. *See, e.g.,* Romanoff Equities, Inc. v. United States, 815 F.3d 809, 812-14 (Fed. Cir. 2016) (affirming that a railway easement may continue to be used for High Line Park in New York City).

236. *See supra* note 115 and accompanying text.

237. JESSE DUKEMINIER ET AL., PROPERTY 871 (9th ed. 2018) ("The traditional termination doctrine . . . may enable not just multiple owners . . . but single owners as well to hold out against attempts to override covenants.").

238. *See supra* note 117.

239. *See, e.g.*, DUKEMINIER ET AL., *supra* note 237, at 876-87 (pet restrictions); *id*. at 887 (reproducing a *Doonesbury* cartoon showing people near a clothesline, with the punchline of a police officer shouting, "Sir! Step away from the laundry.").

240. *See supra* Section II.B.7.

other vehicles on the road, nearly all of which are smaller and more vulnerable.[241]

It is possible that the growth of truck platooning will finally catalyze a more permanent physical separation of trucks from other vehicles on interstate highways.[242] This will probably lead to more efficient road usage and to reductions in death, injury, and property damage from vehicle collisions. It is also possible that when all vehicles are autonomous, it will be easier to integrate lengthy truck platoons into overall traffic patterns without modifying the roads. Our highway system and our driving habits developed before platoons existed, and any increase in the prevalence of platoons will spur changes in both highway infrastructure and the rules of the road, a task that may be easier when all vehicles are autonomous.

Finally, concerns about malicious software hacking will be difficult to address, just as they are in other contexts.[243] Those who wish to harm the transportation infrastructure, just like those who wish to harm other aspects of modern society, are capable of causing enormous damage.[244] As the transportation system grows more automated, it will become more vulnerable to hackers, with potentially grave consequences.[245] Private companies and the public bodies that regulate them will have to be attentive to this type of worrisome behavior as AVs become more common.[246]

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241. *See supra* note 135 and accompanying text. Note that while truck platooning is expected to lead to safer roadways overall, individual users in small vehicles could end up in riskier situations than before, particularly while autonomous and traditional vehicles are still sharing the road.

242. *See supra* note 108 and accompanying text.

243. *See, e.g.*, ZEV WINKELMAN ET AL., WHEN AUTONOMOUS VEHICLES ARE HACKED, WHO IS LIABLE? 13 (2019), https://www.rand.org/pubs/research_reports/RR2654.html [https://perma.cc/SCU2-V6HV] ("The dangers springing from a car being hacked are compounded when one thinks of a fleet of AVs communicating with each other as a network of computers in motion. That makes AVs potentially susceptible to attacks that both scale up and scale out in terms of the damage they could cause.").

244. *See, e.g.*, *id.* at 22 ("Successful commandeering of an AV provides an attacker with a 4,000-pound projectile that they may be able to route as they please to achieve mayhem.").

245. *See, e.g.*, Brett Berk, *The Enemies of the Autonomous Vehicle*, CAR & DRIVER (Nov. 3, 2019), https://www.caranddriver.com/features/a29587219/autonomous-vehicle-enemies/ [https://perma.cc/5P7V-B6YR] ("This leads us to one of the most fearsome features of AVs: their capacity to be compromised by rogue actors. Cars could be taken over remotely and manipulated, militarized, or held hostage for ransom."); *Hackers Could Use Connected Cars to Gridlock Whole Cities*, GA. INST. TECH. (July 29, 2019), https://rh.gatech.edu/news/623759/hackers-could-use-connected-cars-gridlock-whole-cities [https://perma.cc/Z9Z6-H547] (quoting one researcher as saying, "Randomly stalling 20 percent of cars during rush hour would mean total traffic freeze.").

246. *See How to Hack a Self-Driving Car*, PHYSICS WORLD: EVERYDAY SCI. (Aug. 18, 2020), https://physicsworld.com/a/how-to-hack-a-self-driving-car/ [https://perma.cc/F4BB-RL4P] ("The complexity of these cars means researchers don't know all the possible risks or hacks, which makes it tricky to know how to optimize safety.").

Software products may also be marketed to vehicle operators as a method of gaining an advantage over other vehicles.[247] Traffic algorithms will have to develop some rules for determining the right-of-way. It is entirely possible that those who are willing to pay more will enjoy travel advantages, just as they do today with dedicated express traffic lanes on some highways and airline rewards programs. It is also possible that, in at least some contexts, roadway priority will be based on something other than the willingness and ability to pay for it directly, which may lead software developers to market products that allow drivers to jump to the front of the queue illegally. The fact that governments may choose to prohibit these products will not necessarily impede their use, as manufacturers and users of radar detectors can attest.

IV. WHAT SHOULD GOVERNMENTS DO, AND HOW SHOULD THEY DECIDE?

The previous two Parts described specific issues that will arise as the transition to autonomous vehicles progresses and different manners in which government entities can address these issues. This Part IV will look at what governments should do and, more globally, how governments can approach decisions about what to do when they must act or abstain under conditions of considerable ambiguity.

It is possible to envision a variety of possible futures. In one, the autonomous vehicle revolution turns out to have been overhyped, and autonomous vehicles do not take over the market or do so far more slowly than anticipated. If it becomes evident that this is likely to occur and that the autonomous revolution has been massively exaggerated, then governments will likely learn to respond more cautiously. In that case, those governments that acted more tentatively are rewarded: They did not undertake costly measures in response to a set of issues that never arose or that arose slowly enough that they could be dealt with piecemeal over a prolonged period of time.

This version of the future seems unlikely, but it is impossible to know. Perhaps a new scientific breakthrough makes AV technology obsolete, and some new method of transportation becomes preferable. For example, drones might become more prevalent, and the addition of a third dimension to our currently two-dimensional roadway network might solve our traffic and driving problems (and, most certainly, create a whole set of unexpected new ones). Or perhaps regulators observe that the AV revolution they anticipated is really more of a

247. *See, e.g.*, Gareth Cook, *Full Tilt: When 100% of Cars Are Autonomous–Policing with No Tickets*, N.Y. TIMES MAG. (Nov. 8, 2017), https://www.nytimes.com/interactive/2017/11/08/magazine/tech-design-autonomous-future-cars-100-percent-augmented-reality-policing.html?emc=eta1 [https://perma.cc/S97D-9Y4J] (imagining different types of software hacks that allow some AVs to gain an advantage over others).

gradual evolution. In this instance, they will likely respond slowly and be rewarded for their prudence. They can defer tough decisions, not disturb the status quo in politically untenable ways, and amortize costly investments over a longer period. Inertia might cause them to move slowly, and that unhurriedness will lead to a better outcome.

In another possible future, government entities decide to wait and see, not because the AV revolution is slow to materialize, but rather because they are not sure how to react to it.[248] They are reluctant to bet large numbers of tax dollars on technology or regulations that may be misguided or useless, so they waffle.[249] They sit back and decide to let their successors resolve the problem. In this scenario, it seems evident that other, non-governmental actors will step in to fill this breach.[250] Private companies focused on their bottom lines and individual users concerned with their own convenience and comfort may adopt new technology without any input or guidance from government bodies. We have witnessed behavior such as this in the home-sharing and transportation network industries and are seeing it now with scooters.[251]

By the time the government realizes it can no longer wait, it may be too late to stem the tide. In this possible future, private actors make the major decisions. City councils and county commissions then must react as best they can once their choices have been narrowly circumscribed by companies that lobby hard and residents who vote. In fact, this may be the preferred future from the perspective of these companies, who can shape for themselves the ground rules by which they will operate.[252] Government actors may concur, since they do not have to act until their choices have been constrained by their voters and their financial supporters.

In a third possible future, governments act proactively. They may not know exactly what changes are coming and when, but they feel

248. *See, e.g.*, Guerra, *supra* note 121, at 214 (listing uncertainty as the strongest reason why planners have not included autonomous vehicles in their most recent long-range plans and quoting one survey participant as stating, "We used to predict colonies on the moon").

249. *See id.* at 215 ("Wondering about how far the future might deviate from all of the many impacts under consideration, one planner joked: 'I don't want to hear this [interview recording] in 20 years.'").

250. *See* Pearl, *supra* note 37, at 432 ("[T]he need to legislate and regulate proactively in response to emerging technology may be limited and . . . changes in, for instance, the insurance market and consumer behavior will solve many of the problems that we foresee.").

251. *See, e.g.*, Elizabeth Pollman & Jordan M. Barry, *Regulatory Entrepreneurship*, 90 S. CAL. L. REV. 383, 403-06 (2017) (describing start-up businesses that plan from the outset to mobilize satisfied customers so they can change laws that may limit their operations); Adam Clark Estes, *Uber Faces Down Legal Trouble Pretty Much Everywhere*, ATLANTIC (Dec. 3, 2012), https://www.theatlantic.com/technology/archive/2012/12/uber-legal-trouble/320893/ [https://perma.cc/YCZ2-QHK2] (quoting Uber founder Travis Kalanick as saying, "If you put yourself in the position to ask for something that is already legal, you'll find you'll never be able to roll out."); *see also* Jeong, *supra* note 223.

252. Pollman & Barry, *supra* note 251, at 430-34.

pressure to act before private companies, local residents, and competing jurisdictions take the initiative. Fearing a loss of control or a competitive disadvantage, they study the issue and then do something, however premature or ill-advised. The advantage to this approach is that regulators establish the rules of the road before those roads become too chaotic. The disadvantage is that they may guess wrong.[253]

If a regulatory agency miscalculates, it can stifle innovation, harm competition, and guide the public to a result that is not as advantageous as other alternatives might have been.[254] Moreover, legacy industries will oppose developments such as these, which threaten their existing market share.[255]

My aim is not to predict which of these futures is more likely to occur in the world of autonomous vehicles, and different jurisdictions may respond in different ways, each warily eyeing the others. Rather, my goal here is to offer suggestions to policymakers who must make these decisions—or kick the can down the road—and whose crystal balls are no better or worse than mine or anyone else's. This Part IV will offer recommendations as to how these policymakers can act under conditions of significant uncertainty, given the high stakes involved and the potentially disastrous consequences of a misguided decision.

If the question is how to plan for an unpredictable future, one possible approach is to make use of scenario planning.[256] As the Consortium for Scenario Planning states, "Scenario planning is a practice through which communities plan for an uncertain future by exploring multiple possibilities of what might happen. The practice

253. *Cf.* Guerra, *supra* note 121, at 215 (noting planners' concern that widespread adoption of AVs will make highway and rail projects that are currently underway obsolete by the time they are completed).

254. *See, e.g.*, Jordan M. Barry, *Taxation and Innovation: The Sharing Economy as a Case Study*, *in* THE CAMBRIDGE HANDBOOK OF THE LAW OF THE SHARING ECONOMY 381, 381-88 (Nestor M. Davidson et al. eds., 2018) (describing advantages and disadvantages of using tax incentives to encourage innovation).

255. *See, e.g.*, Ill. Transp. Trade Ass'n v. Chicago, 839 F.3d 594, 594-99 (7th Cir. 2016) (unsuccessful constitutional challenges by taxicab and livery service owners and operators to Chicago's adoption of an ordinance that holds ride-sharing services to more permissive standards for operation); Joe Sanfelippo Cabs, Inc. v. Milwaukee, 839 F.3d 613, 614 (7th Cir. 2016) (companion case); *see also* Phila. Taxi Ass'n, Inc. v. Uber Techs., Inc., 886 F.3d 332, 344 (3d Cir. 2018) ("Were we to award Appellants antitrust damages to compensate for their financial injuries, we would condemn vigorous competition, rather than encourage it."); Checker Cab Operators, Inc. v. Miami-Dade County, 899 F.3d 908, 912 (11th Cir. 2018) ("The medallions conferred by the County created a license to offer for-hire taxicab services in Miami-Dade County; the County did not afford the Medallion Holders the right to exclude competition in the marketplace.").

256. *See* PETER SCHWARTZ, THE ART OF THE LONG VIEW: PLANNING FOR THE FUTURE IN AN UNCERTAIN WORLD xiv (paperback ed., 1996) [hereinafter SCHWARTZ, LONG VIEW] ("[T]he point is to make strategic decisions that will be sound for all plausible futures"); *id.* at xvi ("Experience has shown that looking into the future is most useful when it is the beginning, not the end, of a significant conversation.").

guides planners, community members, and other stakeholders through considerations of various futures and how to effectively respond to and plan for them."[257] By taking this approach, professionals can make plans against a background of doubt, project different possible alternatives for the future, and develop policies that support alternative states of affairs.[258] This approach allows them to factor in the pros and cons of various possible courses of action.[259] It also serves as a form of storytelling about alternative possible futures.[260]

Different sources suggest different origins for the concept of scenario planning. Several trace it to efforts by energy company Royal Dutch Shell to decide upon strategies for future exploration and production.[261] For Shell, scenario planning "helped break the habit, ingrained in most corporate planning, of assuming that the future will look much like the present."[262] This allowed "Shell executives to open their minds to previously inconceivable or imperceptible developments."[263] Others claim that scenario planning has military origins, with Shell taking its lessons from the military's earlier use of war games.[264]

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257. *Introduction to Scenario Planning*, LINCOLN INST. LAND POL'Y: CONSORTIUM FOR SCENARIO PLAN., http://www.scenarioplanning.io/scenario-planning/ [https://perma.cc/68LF-FJE2] (last visited Sept. 21, 2020).

258. *Knowledgebase Collection: Scenario Planning*, AM. PLAN. ASS'N, https://www.planning.org/knowledgebase/scenarioplanning/ [https://perma.cc/SY4B-JWHF] (last visited Sept. 21, 2020).

259. Lisa Grow Sun & Brigham Daniels, *Mirrored Externalities*, 90 NOTRE DAME L. REV. 135, 174 (2014) (describing how scenario planning allows for the consideration of both advantages and disadvantages).

260. Robin Kundis Craig, *Cholera and Climate Change: Pursuing Public Health Adaptation Strategies in the Face of Scientific Debate*, 18 HOUS. J. HEALTH L. & POL'Y 29, 59-60 (2018) (describing scenario planning as a form of telling stories about the future).

261. *See, e.g.*, William J. Aceves, *Predicting Chaos? Using Scenarios to Inform Theory and Guide Practice*, 45 VA. J. INT'L L. 585, 612-15 (2005) (describing Shell's experience); Angela Wilkinson & Roland Kupers, *Living in the Futures*, HARV. BUS. REV. (May 2013), https://hbr.org/2013/05/living-in-the-futures [https://perma.cc/75DR-HRVV] (authored by a former Shell scenario planner and a former Shell executive and stating that a majority of U.S. scenario planning studies were based on Shell's process); Paul J.H. Schoemaker, *Scenario Planning: A Tool for Strategic Thinking*, 36 MIT SLOAN MGMT. REV. 25, 25 (1995), https://sloanreview.mit.edu/article/scenario-planning-a-tool-for-strategic-thinking/ [https://perma.cc/27LD-J5CF] (explaining how Shell has used scenario planning since the 1970s).

262. Wilkinson & Kupers, *supra* note 261.

263. *Id.*

264. *See, e.g.*, Charles Roxburgh, *The Use and Abuse of Scenarios*, MCKINSEY & COMPANY: STRATEGY & CORPORATE FINANCE (Nov. 1, 2009), https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/the-use-and-abuse-of-scenarios# [https://perma.cc/8FLJ-YF2B] ("There is a significant amount of literature on scenarios: their origins in war games, their pioneering use by Shell, how to construct them, how to move from scenarios to decisions, and so on."); SCHWARTZ, LONG VIEW, *supra* note 256, at 7 (same).

Whatever its genesis, scenario planning claims to incorporate certain benefits. "[A] sustained scenario practice can make leaders comfortable with the ambiguity of an open future. It can counter hubris, expose assumptions that would otherwise remain implicit, contribute to shared and systemic sense-making, and foster quick adaptation in times of crisis."[265] And it has application well beyond energy exploration and military exercises. Most importantly, scenario planning can help in predicting and guiding land use policy.[266]

Scenario planning is useful in contexts in which the future is most difficult to predict.[267] As one scenario planning expert explains, "Scenarios are not about predicting the future, rather they are about perceiving futures in the present."[268] This can be a helpful approach in planning for problems with contours that are difficult to anticipate precisely, such as climate change.[269] Another author describes an exercise using scenario planning in the context of solar radiation management, in which the technique "generated six scenarios premised on differing levels of stakeholder self-interest and technological controllability."[270] Yet another author discusses the use of scenario planning in evaluating alternative energy management plans.[271] Scholars have also begun to explore how scenario planning can be used to respond to various repercussions of the COVID-19

265. Wilkinson & Kupers, *supra* note 261.

266. *See Introduction to Scenario Planning*, *supra* note 257 ("The practice guides planners, community members, and other stakeholders through considerations of various futures and how to effectively respond to and plan for them.").

267. *See* Daniel A. Farber, *Uncertainty*, 99 GEO. L.J. 901, 933 (2011) (describing the ruling out of unacceptable options and the selection of the most palatable remaining ones); Daniel A. Farber, *Taking Responsibility for the Planet*, 89 TEX. L. REV. 147, 178 (2010) (reviewing DOUGLAS A. KYSAR, REGULATING FROM NOWHERE: ENVIRONMENTAL LAW AND THE SEARCH FOR OBJECTIVITY (2010)) ("In situations where it is impossible to give confident odds on the outcomes, scenario planning may be the most fruitful approach."). Note, though, that "[s]cenarios are *not* predictions. It is simply not possible to predict the future with certainty." SCHWARTZ, LONG VIEW, *supra* note 256, at 6.

268. SCHWARTZ, LONG VIEW, *supra* note 256, at 36.

269. Maxine Burkett, *Duty and Breach in an Era of Uncertainty: Local Government Liability for Failure to Adapt to Climate Change*, 20 GEO. MASON L. REV. 775, 793 (2013) (discussing the use of scenario planning when contemplating foreseeable risks such as climate change); Emma Zehner, *Climate Change: Great Lakes Communities Use Scenario Planning to Prepare for Rising Waters*, LINCOLN INST. LAND POL'Y (Jan. 15, 2020), https://www.lincolninst.edu/publications/articles/2020-01-climate-change-great-lakes-communities-use-scenario-planning-prepare-rising-waters-sea-level-rise [https://perma.cc/CM22-35SV] (describing the use of scenario planning to help plan for potential inland flooding).

270. Albert C. Lin, *The Missing Pieces of Geoengineering Research Governance*, 100 MINN. L. REV. 2509, 2559-60 (2016).

271. Ryan B. Stoa, *From the Clean Power Plan to the Affordable Clean Energy Rule: How Regulated Entities Adapt to Regulatory Change and Uncertainty*, 47 HOFSTRA L. REV. 863, 880-81 (2019).

epidemic.[272] These examples illustrate how difficult it can be today to envision tomorrow's problems.[273] In a similar fashion, some features of contemporary life seemed unfathomable many years ago and might have benefited from thoughtful scenario planning:

> When Brigadier General Billy Mitchell proposed that airplanes might sink battleships by dropping bombs on them, U.S. Secretary of War Newton Baker remarked, "That idea is so damned nonsensical and impossible that I'm willing to stand on the bridge of a battleship while that nitwit tries to hit it from the air."[274]

How does the process of scenario planning work? First, we must identify precisely what the problem is.[275] Next, a diverse group of interested participants must brainstorm this problem and determine "forces that might influence the outcome of the focal issue."[276] Following this brainstorming, the group then narrows the range of possible outcomes to "a small number of scenario plots."[277] The group can then workshop these plots and expand them into lengthier scenario outlines that provide a narrative of each of these possible outcomes.[278] This process is fairly structured and rigorous.[279] The overall goal of the process, of course, is for the relevant community to

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272. *See, e.g.,* Robert Goodspeed, *Q and A: Robert Goodspeed on Scenario Planning for Cities and Regions*, COLUM. UNIV. PRESS BLOG, May 14, 2020, https://www.cupblog.org/2020/05/14/qa-robert-goodspeed-on-scenario-planning-for-cities-and-regions/ [https://perma.cc/9RVV-Z2WJ] ("Local governments, nonprofit groups, and other organizations do not have the luxury of waiting to see what the rate of infection from COVID-19 will be in a year, or how the economic impacts will play out. They need to act now, and yet their decisions will have consequences for years to come.").

273. *COVID-19 Q and A: How Scenario Planning Can Shape Our Recovery Efforts*, LINCOLN INST. LAND POL'Y (Apr. 24, 2020), https://www.lincolninst.edu/publications/articles/2020-04-COVID19-how-scenario-planning-can-shape-pandemic-recovery-efforts [https://perma.cc/KG2C-KX2Y] ("Often hazard and disaster staff are pretty separate from long-range land use and transportation planners. In order to use scenario planning to address this pandemic, practitioners may have to bridge these and other communities. This may eventually foster greater collaboration.") (interview with Robert Goodspeed).

274. Schoemaker, *supra* note 261, at 25 (also noting, "It was probably as hard for them to evaluate the effect of airplanes in the 1920s as it is for us to assess the impact over the next decades of multimedia, the human genome project, biotechnology, artificial intelligence, organ transplants, superconductivity, space colonization, and myriad other developments.").

275. JAMES A. OGILVY, CREATING BETTER FUTURES: SCENARIO PLANNING AS A TOOL FOR A BETTER TOMORROW 175 (2002); *see also* Janae Futrell, *PAS Memo: How to Design Your Scenario Planning Process*, AM. PLAN. ASS'N 1 (July 1, 2019), https://planning-org-uploaded-media.s3.amazonaws.com/publication/download_pdf/PASMEMO-2019-07-08.pdf [https://perma.cc/U6FW-EVU2] ("This *PAS Memo* provides a 'how-to' guide on preparing to implement scenario planning, moving through sequential steps to create a 'roadmap' for the process.").

276. OGILVY, *supra* note 275, at 175.

277. *Id.* at 175-76.

278. *Id.* at 176.

279. Futrell, *supra* note 275, at 4 ("[I]ntentional process design from start to finish contributes to better results and more useful evaluation of the process to feed improvement over time.").

decide for itself which scenarios are more likely than others and to formulate responses appropriate for each of them.[280] By following this approach, the group works to formulate its future together rather than merely selecting options from a generic menu assembled by others.[281]

The American Planning Association ("APA") has advocated for the use of scenario planning in the context of autonomous vehicles "to characterize the range of possible futures and corresponding policy responses that support the community vision and goals."[282] The first step in the APA's approach, community planning, asks stakeholders to envision their community over the coming twenty years, including the role that AVs will play.[283] The community then vets alternative scenarios, selects a preferred one, and amends its comprehensive plan in a way that will encourage the community to move toward that scenario.[284] In the second phase, plan making, the community follows up on this process by adopting more specific policies, such as functional transportation plans, sustainability plans, and economic development plans.[285]

Phase three—regulations, standards, and incentives—shifts the emphasis from planning to implementation.[286] During this phase, the jurisdiction adopts or amends zoning laws, building codes, and similar regulations.[287] The fourth phase, site design and development, is when a given location is actually developed.[288] During this phase, the local government can "manage deployment of AV technology in ways that meet community goals and minimize adverse impacts."[289] The final phase, public investment, is when the jurisdiction invests in infrastructure and facilities such as roadways and technology.[290]

The use of scenario planning seems appropriate when designing for autonomous vehicles, because it allows communities to "construct and analyze multiple versions of the future, leaving ample room to change

280. OGILVY, *supra* note 275, at 176-77.

281. *Id.* at 186 ("If the choice that is made is a choice of a strategy that was not *given to* the community but *created by* the community, then the community will more likely assume *ownership* of that choice.").

282. APA, PREPARING COMMUNITIES, *supra* note 59, at 20.

283. *Id.* at 20-21.

284. *Id.* at 22.

285. *Id.* at 22-25.

286. *Id.* at 28-31.

287. *Id.* at 28.

288. *Id.* at 31-33 (providing a checklist of questions and elements to consider). Note that private and public developments may raise slightly different issues during this phase. *Id.* at 31.

289. *Id.* at 31.

290. *Id.* at 31, 33-34.

course as unexpected wrinkles arise."[291] This approach is continually adaptive, allowing for flexibility as conditions evolve without committing to projects that may be costly and difficult to change.[292] And "[w]hen conditions on the ground indicate that one of the scenarios is more likely, that's the trigger for going all-in on infrastructure, policies, and placemaking."[293] Moreover, scenario planning facilitates buy-in by diverse and competing local constituencies.[294] This increases the likelihood that proposals will not only be adopted but also be accepted by constituents.[295]

Scenario planning is used as a substitute for forecasting.[296] Its underlying premise is that one should prepare for an indeterminate future rather than attempting to predict it.[297] Instead of assuming that a given scenario will come to pass and then organizing around it, scenario planning accepts that multiple different scenarios could

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291. Anthony Flint, *Land Matters Podcast, Episode 7: Designing the Future City*, LINCOLN INST. LAND POL'Y (Nov. 20, 2019), https://www.lincolninst.edu/publications/articles/2019-podcast-designing-future-city [https://perma.cc/997G-87Y2].

292. *Id.*; *see also* Jeremy Carp, *Autonomous Vehicles: Problems and Principles for Future Regulation*, 4 U. PENN. J.L. & PUB. AFF. 81, 139 (2018) (arguing for planned adaptive regulation and noting that "it makes far more sense to approach regulation in this context as an iterative process, with the first regulations of autonomous vehicles as an initial step, rather than the ultimate goal.").

293. Flint, *supra* note 64.

294. *See* Deirdre K. Mulligan & Kenneth A. Bamberger, *Saving Governance-By-Design*, 106 CAL. L. REV. 697, 782-83 (2018) ("Scenario planning may be particularly useful when there is a need to think about possible futures in a collaborative and explicit manner."); Roxburgh, *supra* note 264 ("Scenarios allow companies to . . . provid[e] a political 'safe haven' for contrarian thinking.").

295. Robert Goodspeed, *Scenario Planning: Embracing Uncertainty to Make Better Decisions*, LINCOLN INST. LAND POL'Y (Mar. 2019), https://www.lincolninst.edu/sites/default/files/pubfiles/scenario-planning-policy-brief.pdf [https://perma.cc/V7CZ-LB5F].

296.

> Scenario planning is not a tool for making predictions. . . . Rather, it is a tool for better decision making. The test of good scenario planning is not whether the scenario accurately predicts the future. Rather, the measure of good scenario planning is whether we made a better decision as a result of having considered the possible scenarios.

Peter Schwartz, *Preface*, *in* JAMES A. OGILVY, CREATING BETTER FUTURES: SCENARIO PLANNING AS A TOOL FOR A BETTER TOMORROW vii (2002).

297. *Id.*

occur, each requiring a different plan.[298] Considering alternatives in this way reduces the risk that a planner will be taken by surprise.[299]

One expert refers to scenario planning as "rehearsing the future," although "rehearsing alternative possible futures" seems more accurate.[300] This approach prepares for different futures that could occur rather than seeking to achieve a particular normative goal.[301] Those options and responses, if any, that appear fruitful under more than one scenario will be the most promising ones to pursue.[302] Scenario planning thus builds in and accounts for uncertainty that other types of preparation might overlook.[303] "In the end what you are after is a strategy for all seasons."[304]

The presence of certain elements makes scenario planning most useful. One expert summarizes a list of conditions under which scenario planning offers the greatest benefits.[305] Some of these qualities are not particularly relevant to planning for autonomous vehicles, but four of them are: "[u]ncertainty is high relative to [the] ability to predict or adjust," "[t]he industry has experienced significant change or is about to," "[t]here are strong differences of opinion, with multiple opinions having merit," and, fairly likely, "[y]our competitors are using scenario planning."[306] Under these conditions, the future is particularly hard to predict.[307]

If scenario planning appears to be a useful technique to land use planners, then those planners must proceed to develop scenarios. This process involves numerous steps designed to envision alternative

298. *Id.*; *see also* Goodspeed, supra note 295 at 2 ("These projects create multiple hypothetical future scenarios, based on both changing trends and potential decision making, allowing planners to analyze uncertainties beyond city or regional control."); SCHWARTZ, LONG VIEW, *supra* note 256, at 195 (discussing "why scenario-planners avoid single predictions").

299. Jay Ogilvy, *Scenario Planning and Strategic Forecasting*, FORBES (Jan. 8, 2015), https://www.forbes.com/sites/stratfor/2015/01/08/scenario-planning-and-strategic-forecasting/#61d8d6df411a [https://perma.cc/4Y66-TMFU] (sponsored article).

300. *See* SCHWARTZ, LONG VIEW, *supra* note 256, at 191-93. The author follows by noting, "You run through the simulated events as if you were already living them. You train yourself to recognize which drama is unfolding. That helps you avoid unpleasant surprises, and know how to act." *Id.* at 192.

301. Goodspeed, *supra* note 295. Note, however, that this type of exploratory scenario planning is to be distinguished from normative and predictive scenario planning. *See infra* note 307.

302. Ogilvy, *supra* note 299.

303. Goodspeed, *supra* note 295.

304. OGILVY, *supra* note 275, at 177.

305. Schoemaker, *supra* note 261, at 27.

306. *Id.*

307. One author refers to scenario planning under these conditions as "exploratory scenario planning," in contrast with "normative scenario planning," which aims to achieve a particular goal, and "predictive scenario planning," which seeks to ascertain which future is most likely to occur. Futrell, *supra* note 275, at 4-5. She also notes that "the primary purpose of *exploratory* scenario planning is to navigate uncertainty." *Id.* at 5.

futures, engage all the major players in the process, determine what additional information is needed, and refine the options.[308] These alternative futures should be plausible—ones that actors can envision themselves participating in—even if they are not probable, and they should be sufficiently quantitative to be persuasive.[309] At the same time, they should not merely be extensions of the present.[310] The overall goal is to develop scenarios that are relevant, effective, and useful, while being alert to built-in biases that might undercut those goals.[311] In addition, these scenarios should not hinder innovation.[312]

In the land use context, scenario planning might require government officials, industry experts, local citizens, and others to brainstorm possible outcomes, which is an acknowledgment that they are not fully in control of the future.[313] They might list the uncertainties that they are aware of, and try to predict the "known unknowns" and "unknown unknowns" that could appear in the future.[314] With this background, they can try to foresee alternative futures and estimate how likely each of these alternatives is to come to pass.[315] They can then test each alternative scenario against the others.[316] Once they select a tentative approach from among their alternatives, they can monitor that one and the others against events that subsequently occur, which will allow them to adapt and change course more nimbly than if they had not gamed out the alternatives.[317]

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308. Schoemaker, *supra* note 261, at 28-29.

309. Wilkinson & Kupers, *supra* note 261.

310. *Id.*; *see also* Roxburgh, *supra* note 264 ("By demonstrating how—and why—things could quite quickly become much better or worse, we increase our readiness for the range of possibilities the future may hold.").

311. Schoemaker, *supra* note 261, at 29.

312. U.S. DEP'T OF TRANSP., USDOT COMPREHENSIVE MANAGEMENT PLAN FOR AUTOMATED VEHICLE INITIATIVES 5 (2018), https://www.transportation.gov/sites/dot.gov/files/docs/policy-initiatives/automated-vehicles/317351/usdot-comprehensive-management-plan-automated-vehicle-initiatives.pdf [https://perma.cc/J4XU-NL8J] ("DOT's goal is to prepare for this new era of transportation by engaging with these new technologies to ensure safety without hampering innovation. To achieve this goal, we will modernize transportation policies and regulations to respond to these rapidly evolving technologies, without prejudging these technologies and their capabilities.").

313. *See* OGILVY, *supra* note 275, at 12 ("Scenario planning is based on a contrary assumption, that the future cannot be predicted and that belief in the possibility of total control is a dangerous delusion. Because all things are interrelated, you'll never keep surprises in one part of the universe form affecting some other part you're trying to control.").

314. *See* Paul Schoemaker, *How to Prepare for the Unexpected*, INC. (July 17, 2012), https://www.inc.com/paul-j-h-schoemaker/scenario-planning-prepare-for-unexpected.html [https://perma.cc/36KG-GHV9].

315. *Id.*

316. *See id.* (listing steps that include "Assess the plausibility of each scenario" and "Eliminate combinations that are implausible").

317. *See* Paul Schoemaker & Arjen van den Berg, *7 Ways to Apply Scenario Planning*, INC. (July 30, 2012), https://www.inc.com/paul-schoemaker/7-keys-to-scenario-planning.html [https://perma.cc/9Z69-WKKX] (noting that "[g]ood monitoring requires systematically

This approach will "encourage attention to the future's openness and irreducible uncertainty."[318] It serves to educate, increase awareness, determine strategic direction, and identify actions, all of which will be important as AVs become more prevalent.[319] Finally, it recognizes, accepts, and plans for ambiguity.[320]

CONCLUSION

This Article has attempted to portray the more and less likely consequences of the upcoming autonomous vehicle revolution. It has encouraged planners to recognize that these changes are coming, has laid out and described some reasonably foreseeable changes, and has offered more conjectural predictions as to second-order transformations that could result later on. Land use planners are already contemplating these changes and are beginning to recognize that they need to act, and quickly.[321]

The problem these planners face, not surprisingly, is that they do not know what to do. Technological change is hard to predict, and responding to it is risky and potentially costly. In some cases, government officials decide to bide their time, or they simply stall without making any affirmative decisions at all. They may fear acting too precipitously and wasting resources on inaccurate guesses.

If these leaders decide not to act, or simply delay until others act first, they risk responding too slowly and too late. By the time they proceed, private actors may have already invested in new technologies, citizens may have adopted them, and the pressure to conform to these actions will be too great to resist. If this is what happens, then governments will have abdicated their responsibilities, yielding

scanning leading indicators plus the ability to link key signals to tactical or strategic adjustments of the plan").

318. Wilkinson & Kupers, *supra* note 261.

319. Futrell, *supra* note 275, at 5.

320. *See* Wilkinson & Kupers, *supra* note 261.

321. Some scholars have suggested recently that the AV revolution may not arrive as quickly as others first anticipated. *See, e.g.*, Wendell Cox, *Driverless Cars and the City: Sharing Cars, Not Rides*, 18 CITYSCAPE 197, 202 (2016) ("Cities evolve. They are not transformed in the short term. Truly transformational cities are rare and are designed and built from scratch. Switching to driverless cars will not be like building and opening a Brasilia, but rather more like slowly retrofitting Rio de Janeiro . . . ."); *see also* Winnie Hu, *Driverless Cars Arrive in New York City*, N.Y. TIMES (Aug. 6, 2019), https://www.nytimes.com/2019/08/06/nyregion/driverless-cars-new-york-city.html?action=click&module=News&pgtype=Homepage [https://perma.cc/8PH2-JL68] (quoting Samuel Schwartz as saying, "In 2017, autonomous vehicles were two years away from hitting the street. . . . In 2019, they are at least five years away. Just about everybody that promised autonomous vehicles by 2019 has retrenched. It's far more complicated than they imagined."); Neal E. Boudette, *Despite High Hopes, Self-Driving Cars Are 'Way in the Future'*, N.Y. TIMES (July 17, 2019), https://www.nytimes.com/2019/07/17/business/self-driving-autonomous-cars.html [https://perma.cc/48PH-E8MT] ("'We overestimated the arrival of autonomous vehicles,' Ford's chief executive, Jim Hackett, said at the Detroit Economic Club in April.").

decision-making power to a private sector that is acting on behalf of its shareholders and not the overall public.

If government entities need to act soon, however, they next must decide what actions to take, and they need to do so under conditions of considerable risk and uncertainty. That is where scenario planning may prove helpful. By considering and weighing numerous alternatives, government agents are less likely to disregard the ones that prove to be important. By leaving their options open as long as they can, they are less likely to pull important alternatives off the table too soon. Using this approach increases the public's perception that all voices are being heard and reduces the likelihood of misguided decisions.

The legal transformations that are likely to occur in the coming decades will be of enormous interest and importance to legal scholars and the general public. The study of patterns of land use, the interactions among citizens that must share crowded public spaces and work together within them, and the development of new technologies that improve the human condition are central humanistic endeavors that illustrate the importance of law to all citizens. We will all need to cooperate in a dramatically different world to negotiate a new jurisprudential social contract.