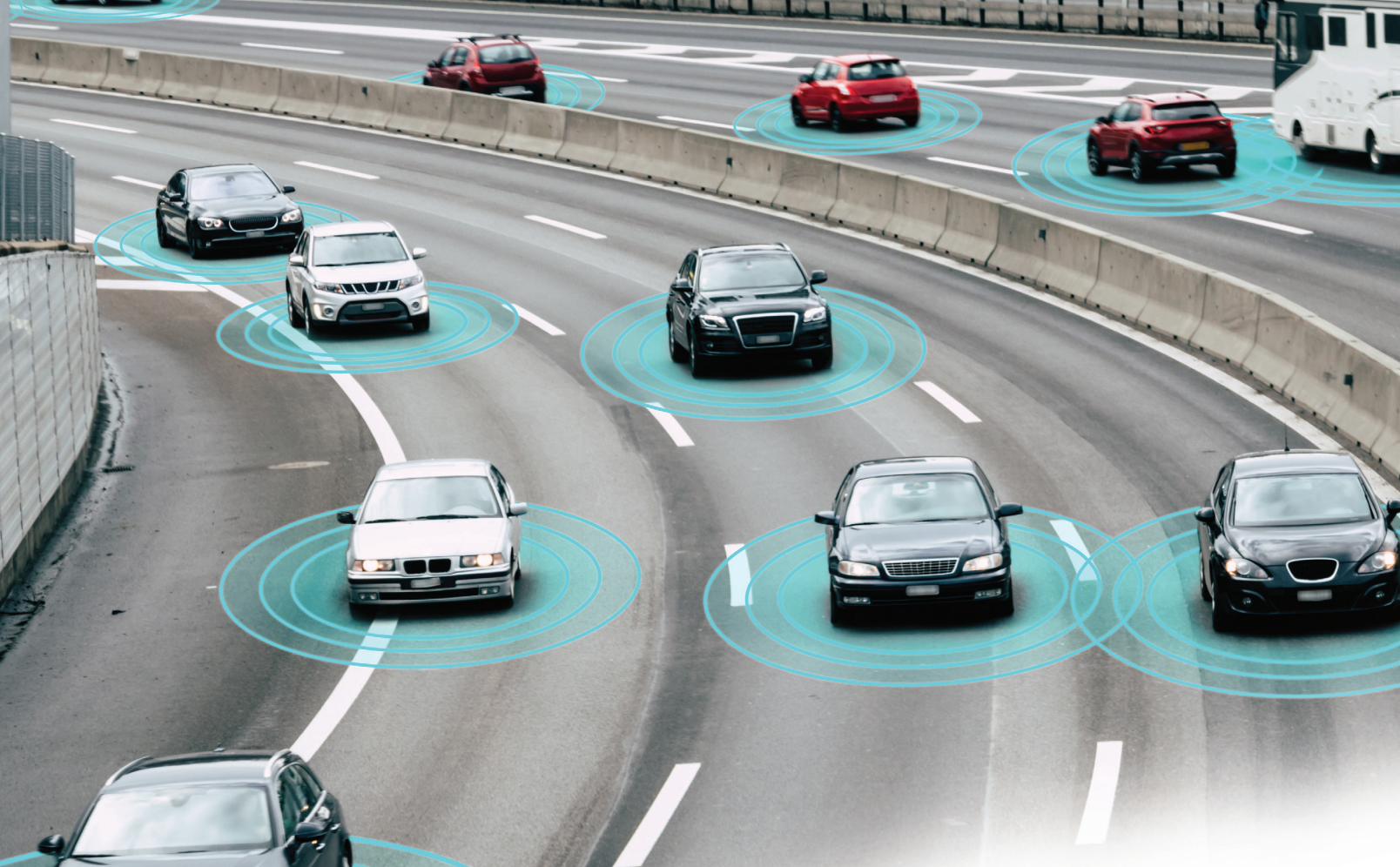


SELF-DRIVING VEHICLES

How will they impact us and why should we care?

BY RYAN HARGROVE

About a year ago, my wife and I took a weekend trip to Las Vegas, Nevada. After enjoying dinner out at a popular restaurant one evening, I opened the Lyft app on my phone to order a ride back to our hotel. Upon doing so, I received a message indicating we were eligible to be matched with one of the first self-driving vehicles on the Lyft network. My wife and I were intrigued, having never ridden in a self-driving vehicle (SDV) before, and we eagerly accepted Lyft's self-driving-ride invitation.

There were two Lyft representatives in the front of our SDV when it arrived, which was a bit ironic (since the vehicle was supposed to drive itself). One person was a safety driver, ready to take over if the SDV failed. The other was responsible for keeping track of system performance and labeling data on a laptop. Both also served as de facto tour guides for our self-driving-ride experience.

There was a high-tech screen in our SDV that showed cars and objects on the road. We witnessed our SDV making lane changes on its own. It was also explained to us that city regulations required SDVs to be driven manually on hotel properties. Overall, the ride was a fascinating experience and we arrived at our destination in a comfortable and efficient fashion. The experience inspired me to conduct research on the future of SDVs and how they'll impact us moving forward.

SDV Technology

According to an email Lyft sent me in connection with our Las Vegas ride, the Lyft SDVs use a collection of different sensors to perceive the world around them, including cameras, radar and LiDAR. The cameras work like human eyes, picking up things like lane markings, pedestrians and traffic signals. The radar sensors use radio waves to detect pedestrians and other vehicles, and to understand how they're moving relative to one another. The LiDAR sensors use small laser pulses to build a three-dimensional map of the environment and all the objects in it.

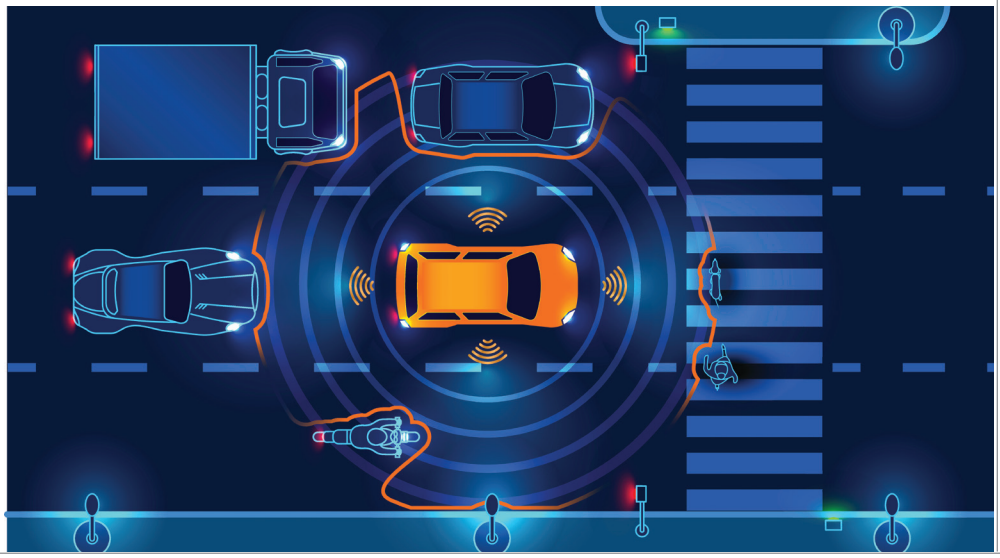
It's worth mentioning that while most of the industry is incorporating LiDAR into SDVs, Elon Musk of Tesla has described LiDAR as expensive and unnecessary. Moreover, at Tesla's 2019 Autonomy Day he stated, "LiDAR is a fool's errand. Anyone relying on LiDAR is doomed."

Current Status of SDVs

According to the Society of Automotive Engineers, there are six levels of SDVs, numbered zero to five. Level Zero represents no automation while Level Five represents full automation. Levels One through Four represent everything in between. Most existing SDVs fall into the Level One and Two categories while Level Three systems are just being introduced.

Level Five SDVs are still years away according to a 2019 Popular Mechanics article entitled "When Are Self-Driving Cars Actually Coming?" by Anthony Alaniz. Sam Schwartz, a leading transportation engineer, agrees that Level Five SDVs still require substantial development time in a recent episode of "The Eminent Domain Podcast." Schwartz believes the first wave of widespread SDV use will involve highly structured circumstances, such as buses on fixed routes.

Bryant Walker Smith, a law professor specializing in SDVs, indicates in a Los Angeles Times article entitled "Tesla Has a Huge Incentive to Deploy Self-Driving Tech But is the World Ready?" that to conquer the Level Five challenge, SDVs would need be capable of successfully transporting a sleeping occupant from "downtown Manhattan to the mountains of Maine in the wintertime." In a 2017 interview on Bloomberg Television, Apple CEO Tim Cook called Level Five development of the SDV "the Mother of all AI Projects."



SDV Advantages

SDVs offer numerous potential advantages including:

- **Reduced Collisions, Injuries and Deaths**
  SDVs promise fewer distractions and quicker reaction times, resulting in less collisions, injuries and deaths. Additionally, they can be programmed to mitigate passenger impacts when collisions are imminent (e.g. by spinning around so the collisions occur at their rear).

- **Increased Productivity**
  Commuters will be freed to engage in a variety of productive activities since their attention won't be focused on driving.

- **Increased Independence and Mobility**
  Seniors and those with impaired vision or deficiencies in motor skills will have a readily available transportation option, and gaps in access to public transportation will be filled in.

- **Fewer Household Vehicles**
  SDVs will serve multiple members of a household with drop-offs and pickups occurring at different locations and/or at different times.

- **Reduced Fuel Consumption**
  SDVs will utilize platooning—a strategy where vehicles drive behind one another in tight formation—to save fuel both by reducing wind resistance and using roads more efficiently.

- **Quieter Roads**
  Sirens and horns are tools used by humans to communicate with each other. Their usage will be mostly unnecessary with SDVs.

SDV Challenges

There are also challenges and potentially negative impacts associated with SDVs including:

- **Environmental**
  It's anticipated that more miles will be driven overall as empty SDVs go back out on the road rather than remaining parked. On working days, many SDVs will complete a "double commute." Additionally, the convenience of SDVs may lead to a surge in transportation demand. In a Cornell Real Estate Review blog, Jason Henderson noted that whether vehicle-miles traveled increases or decreases and what SDVs' underlying power source ends up being will be the two biggest determinants of the environmental impacts of SDVs.

- **Software Concerns**
  SDV software will meticulously log and track the locations of SDV riders and has the potential to be hacked by wrongdoers desiring to intercept SDV control.

- **Industry Disruption**
  The taxi, parking and trucking industries will be negatively impacted. Auto dealers, auto insurance providers, rental car companies, the oil industry and personal-injury attorneys may suffer as well.

- **Accident Responsibility**
  If an SDV crashes, who's responsible? Anthony Alaniz points out that "we don't know yet, and insurance companies aren't eager to head to court to figure it out."

- **Government Regulation**
  The lack of federal rules governing SDVs and the need for thorough vetting of the reliability of the technology will impede the adoption rate.

- **Unique Driving Ecounters**
  SDVs will be challenged by potholes, dogs, pedestrians, skateboarders, bicyclists, deer/wild animals and panhandlers attempting to wash SDV windshields.

- **Unique Human Interactions**
  SDVs will have difficulty interpreting and reacting to signals from human drivers such as nodding, waving and making eye contact to announce intentions.

The Early Automobile Analogue

The automobile was developed in 1886 by Karl Benz. In the U.S., it was initially unclear how the transportation system would evolve around automobiles. There was a lot of optimism about them, but there were also concerns.

In 1899, Henry Bliss was the first pedestrian killed by an automobile in the U.S. The taxi driver that struck him was initially arrested and put in jail. However, he was later released. In March 2018, Elaine Herzberg was the first pedestrian killed by an SDV in the U.S. She was struck by an Uber test vehicle, which was operating in self-drive mode with a distracted human safety driver sitting in the driving seat. These tragic events both involved new driving technologies being incorporated into roadways that hadn't been designed to accommodate them.

Determining who deserved blame for these unfortunate fatalities was challenging. Additionally, each tragedy generated public fear about the safety of the associated technologies. According to the podcast, "The Fault in Our Cars," in the 1920s, pedestrians were barred from accessing streets and the perceived ownership of roadways shifted from pedestrians to cars; it's generally been that way ever since.

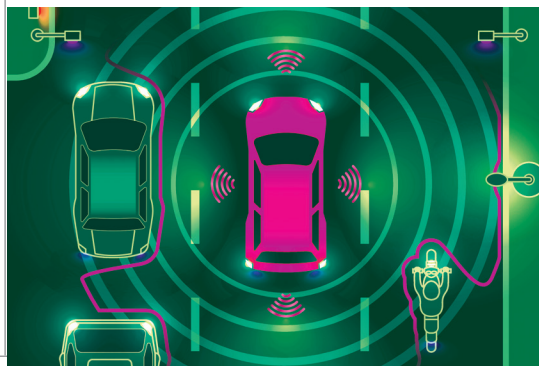
The current rules of the road were written with human drivers in mind. Such rules will need to be revisited and rewritten as SDVs become ubiquitous. We're in a challenging gray area with SDVs currently; the human is mostly passive but still needs to be ready to jump into action when needed. Sam Schwartz suggests there will be a 30-year phase-in period for SDVs, roughly similar in length to the phase-in period experienced by the early automobile.

The Passenger Elevator Analogue

The passenger elevator is another invention that revolutionized human mobility. However, it wasn't well-received by its first users, according to a CNN Style article entitled "A Short History of the Elevator." Initially installed in 1857 at a department store in New York, it was shut down after three years due to lack of use.

Lee Gray, an architectural history professor, is quoted in the article stating, "Mechanized hoisting devices had existed since the early 1800s, but the transition from carrying goods to carrying people happened in the late 1850s. That required a complete transformation of the technology, because early freight hoists had no cars: they were simply open platforms and, therefore, very dangerous."

A focus on safety ultimately increased the public's acceptance of passenger elevators. Elevators today are among the safest forms of transport. Newer buildings with many elevators are starting to employ a system called destination dispatch. Users select which floor they want to go to and then board the car indicated by the system. As Lee Gray points out, "The idea is to take advantage of computers to get the most efficient traffic flow in a building. The technology does everything for you. It's not exactly like [an SDV], but it has a similar feel."



Potential Real Estate Industry Impacts

The real estate industry stands to be impacted significantly by SDVs. Examples of such impacts include:

- **Reduced Parking**
  Land currently used for parking will be developed with other uses since SDVs can drive home and come back when needed. The Cornell Real Estate Review blog points out that parking will also be uncoupled from buildings and placed in more centralized areas.

- **Parking Design Changes**
  If empty SDVs park themselves, parking spaces will be smaller since the doors of empty SDVs won't need to be opened by passengers. Additional design changes will include parking structures built to allow for future conversion to office or retail space, as well as replacement of existing street parking with vehicle drop-off and pickup zones. An offshoot of the elimination of street parking, however, will be loss of municipal parking meter revenue.

- **Acceptance of Longer Commutes**
  Workers likely will be willing to commute farther if it's a better and more productive experience.

- **Elimination of Close-In Location Advantages**
  With acceptance of longer commutes, office projects will be located farther from urban centers, according to a 2018 CBRE study entitled "Autonomous Vehicles: Driving Change for Real Estate." Furthermore, according to "Autonomous Vehicle Technology: A Guide for Policymakers," a report produced by the Rand Corporation, "just as the rise of the [early] automobile led to the emergence of suburbs and exurbs, so the introduction of [SDVs] could lead to more dispersed and low-density patterns of land use surrounding metropolitan regions."

- **Increased Traffic in Certain Locations**
  Downtowns may become busier as people opt out of public transit.

- **Functionally Obsolete Garages**
  Large garages may become less important to the single-family home market because families may no longer want multiple cars, according to a Valuation Magazine article entitled "Driving Change: How the Transportation Revolution Affects Real Estate." Part of a large garage might even be converted into extra living space.

Potential Right of Way Industry Impacts

According to an instructional video produced by the Great Courses entitled "Robotics: Self-Driving Vehicles," by some estimates, only five percent of a typical road is occupied by vehicles. Additionally, cars cost an average of $35,000 apiece in the U.S. and are used only four percent of the time, according to an AI Weekly article entitled "How Self-Driving Cars Could Reduce Emissions, Eliminate Parking Spots and Add $1.3 Trillion to the U.S. Economy" by Kyle Wiggers. These statistics highlight an opportunity for SDVs to increase efficiencies in the use of our vehicles and roads.

The right of way industry stands to be impacted significantly by SDVs. Examples of such impacts include:

- **Changes in Our Roads**
  Platoons of SDVs will use road space more effectively, resulting in less congestion. Cars that crash very infrequently will be smaller and lighter, allowing for further efficiencies in road use. Dedicated SDV lanes and curb redesigns will help allow the full value of SDVs to be achieved.

  In "The Great Race: The Global Quest for the Car of the Future," author Levi Tillemann notes that SDVs might be capable of driving "on roads that look more like tracks – with just enough width for precisely calibrated vehicles to glide along." Although the average car is about six-feet-wide, U.S. Interstate vehicle lanes are twelve-feet-wide to accommodate for human-driver error. Sam Schwartz suggests a narrower, seven-foot-wide highway lane might be appropriate for SDVs, considering their anticipated precision.

  Sam Schwartz also points out the average highway lane currently handles 1,800 to 2,000 vehicles per hour (vph) but predicts a dedicated-SDV highway lane will be able to handle 3,600 vph. Eric Sundquist, Managing Director of the State Smart Transportation Initiative, is quoted in an ITSdigest article stating, "An even more aggressive estimate, taking

into account the possibility of [SDVs] platooning in a 'hypothetical continuous train,' could raise capacity even further, to 8,000 vph at 60 mph, or 10,000 vph at 80 mph."

As the human population expands, these developments will potentially save countries billions of dollars on unneeded road expansion. Some prognosticators even suggest existing roads should be narrowed in the future, allowing for features like wider sidewalks, tree lining, retail patio seating and storm-water runoff filtration.

- **Difficult Public Project and Planning Decisions**
  According to a post on the Driverless Car Market Watch blog entitled "We Need a Moratorium on New Public Transport Projects," current planning and estimation processes for infrastructure projects "cannot and do not take SDVs into account but it's now clear that SDVs will fundamentally change our traffic patterns. This greatly increases the risk that public transport projects will already be obsolete at the time they're completed." The author, Dr. Alexander Hars, further suggests that municipalities should institute temporary moratoriums on new infrastructure projects. Schwartz echoes this sentiment, indicating he discourages overbuilding of traffic infrastructure that doesn't adequately account for SDVs.

  In "The Fault in Our Cars," Seth Stevenson asks: "What are streets for? Do they exist to help vehicles move around quickly and easily or are they places for people, where you can stroll around, meet friends and get coffee or go shopping?" Schwartz suggests we consider returning additional roadway space generated by SDVs to pedestrians, bicyclists, skateboarders and the like.

  A techcrunch.com article entitled "How Many American Cities Are Preparing for The Arrival of Self-Driving Cars? Not Many" notes that "if suburban governments shirk at designing better, more compact physical space, the additional efficiencies and comforts of [SDVs] will just induce longer commutes and more sprawl, which is bad for the environment."

- **Lower Taxes**
  Minimizing road and highway expansion projects might lead to reduced local taxes.

- **Public Transit and Toll Road Usage**
  Mass transit projects may decline. Additionally, toll road usage may decline, as shorter commute times may not be valued as much if people are freed from the responsibility of driving.

- **Expandability**
  Self-driving technology will be applied to trains, trucks and buses. The potential exists to overhaul our transportation networks. As examples, Budweiser has pilot-tested intrastate delivery of goods using SDVs and UPS has recently used them to haul cargo between Phoenix and Tucson, Arizona.

Conclusions

Younger generations are not that enthralled by driving. In fact, only about half of millennials obtained a driving license by age 18, according to Kyle Wiggers. Conversely, young people tend to embrace technological advancement. Seth Stevenson mentions, "Very few people doubt that [SDVs] are coming. The adoption of the technology seems inevitable but, for now, the software is not perfect. It still makes mistakes." A Sustainable America article entitled "Will Self-Driving Cars Reduce Emissions?" notes, "one thing nearly all experts agree on is that the autonomous evolution is coming, and we shouldn't wade in blindly."

The early automobile and the passenger elevator are interesting analogues for SDVs. Both technologies faced significant hurdles and initial public resistance, particularly regarding safety. SDVs face similar issues. These antecedent technologies were ultimately able to conquer safety concerns, win public acceptance and revolutionize society. Will SDVs be able to do the same?

Russ Mitchell opines that premature deployment of SDV technology would result in crashes, injuries and deaths. It would damage public trust in the technology and set the field back by years. In a 2018 blog post entitled "The Positive Risk Profile of Self-Driving Cars," Dr. Hars points out there's a two-sided distribution of safety outcomes with SDVs. They'll likely prevent many accidents (positive outcome) and may cause some accidents (negative outcome). Uncertainty about negative outcomes will need to be critically weighed against the certainty of positive outcomes. Delaying the use of SDVs for too long may cause harm in terms of accidents that could've been avoided.

In the "The Fault in Our Cars," Tom Standage points out that, "When your city has an argument about whether there should be congestion charging or whether there should be higher taxes on Uber, it's really all of those little decisions that are going to shape the future. It's really important that we don't just think about it in a tactical way, but we step back and say what's the final vision that we want and how will these decisions that we're making today contribute to that?"

Momentum for SDVs is strong. The technology promises to bring about intriguing changes, many of which are discussed herein but some of which are yet to be anticipated. I encourage you to stay abreast of this evolving technology and to voice your opinions about it, as it seems destined to make a large impact on our lives, both personally and professionally. The next time you order an Uber or Lyft, be aware that an SDV may be just around the corner. ✪

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