# Our Driverless Futures: Community Forums on Automated Mobility

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Consortium for Science, Policy & Outcomes
at Arizona State University

# *Introduction*

Welcome to *Our Driverless Futures: Community Forums on Automated Mobility*!

We have invited you to take part in *Our Driverless Futures* to help decision makers learn about your views on the future of driverless mobility. Mobility refers to all the ways in which we travel. Some of us walk or use a wheelchair, bike, drive, or take public transportation. By "driverless" we mean systems that could be fully automated, reducing or eliminating control of vehicles by human drivers.

Supporters of driverless mobility hope to increase road safety, provide new transportation options for people, and improve environmental sustainability. Many of these potential benefits, however, are very uncertain. They depend on how these systems are developed. Some experts are concerned that driverless mobility systems could have negative effects, presenting both safety and ethics problems.

At the *Our Driverless Futures* forum, you will share your views with fellow citizens. This booklet provides basic information about the current state of driverless mobility technology and the stakeholders who are currently involved.

Driverless mobility systems are not yet ready for large-scale deployment. Now is the perfect time for you to share your voice about the potential for a driverless future! What do you want the future of mobility to look like? Do you want driverless mobility systems to play a role, or would you prefer to explore other mobility solutions? We look forward to hearing your opinions and making your views known to decision makers and to the public.

## How to read the booklet:

This booklet has four sections that follow the four main discussions that will take place during the forum:

1. The **first** section is a brief history of transportation in the United States. The section describes how transportation evolved during the twentieth and twenty-first centuries and which technologies we still use today. It also discusses the history of driverless mobility.

2. The **second** section provides information on driverless mobility technology. It explores some reasons that the technology was developed and looks at how current designs of the technology actually work.

3. The **third** section discusses areas of uncertainty surrounding driverless mobility systems. Many of the potential benefits of the technology depend on how it is developed and how it is used. This section explores some of those tradeoffs.

4. The **fourth** section is about decision makers. Different companies and government agencies have played roles in the transportation industry in the past. These roles could change, however, with driverless mobility.

## How the forum will work:

The forum consists of 5 sessions plus a short introduction at the beginning and evaluation at the end of the day. Each session focuses on a different topic related to driverless mobility. The sessions build on each other throughout the day, as you begin to piece together what your ideal mobility future looks like and whether it includes driverless systems.

**Session 1 – My Driverless Routine Today**
*What is your present mobility situation and what effect might driverless mobility have on it?*

**Session 2 – Automated Systems, Trust, and Confidence**
*Would you be willing to give up control of a vehicle to an automated computer system and under what conditions?*

**Session 3 – Future Automated Transportation Scenarios**
*What development model do you prefer and how do various tradeoffs affect this preference?*

**Session 4 – Who Decides?**
*Who do you trust to govern this technology? What role should they play?*

**Session 5 – Local Session**
*Weigh in on issues being discussed by decision makers in your area.*

During the forum, you will be seated at a table with other citizens and a trained facilitator. Some sessions will include a short video or briefing that will be read by the facilitator to review information in this booklet. You will then have the opportunity to discuss a variety of issues, weigh different options, and create a plan for the future of mobility both as a group and individually.

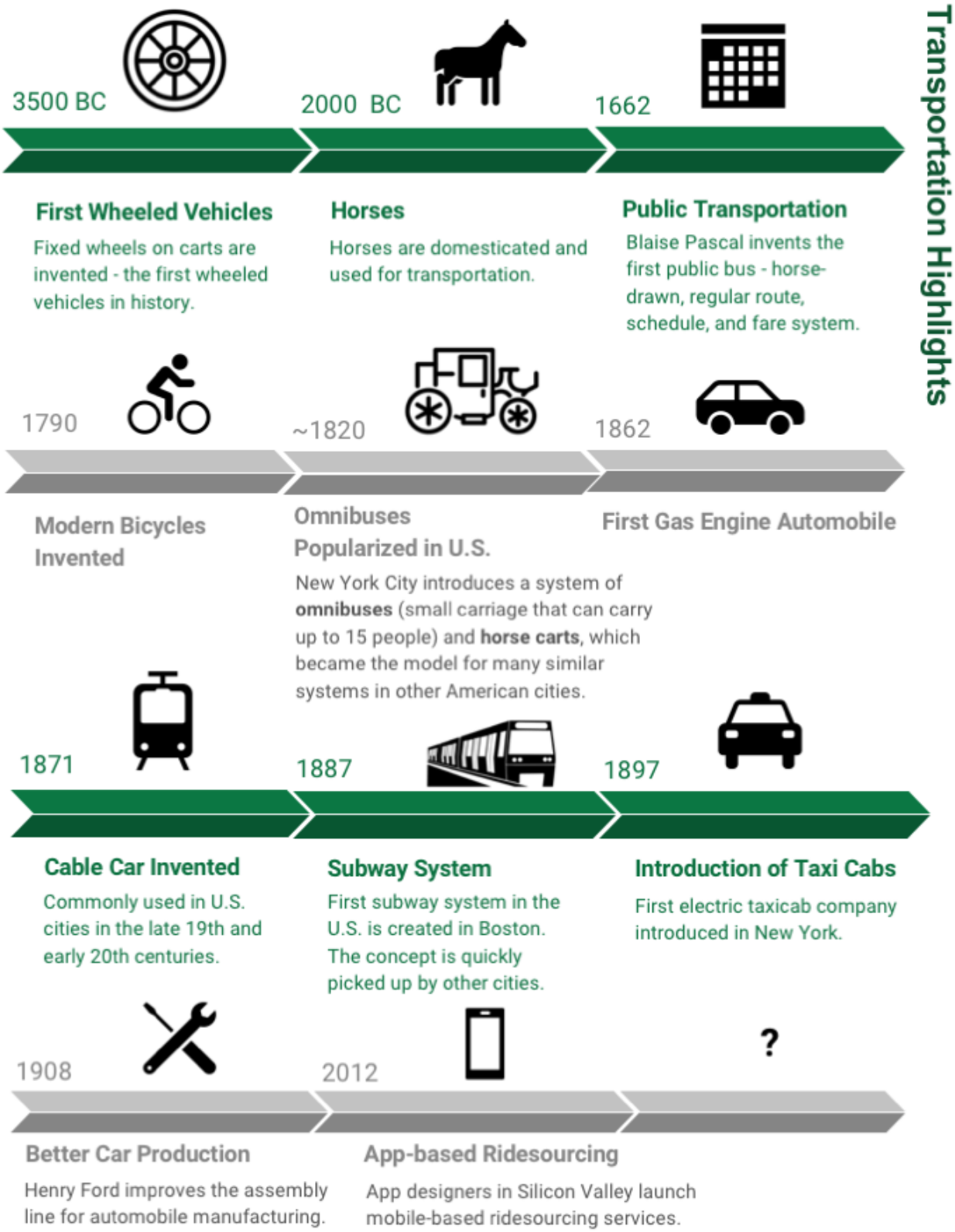
**How this document was produced:**
This booklet was written by the Consortium for Science, Policy & Outcomes in Washington, DC. A Technical Advisory Committee reviewed the information to determine that it is accurate, sufficient, and balanced, based on the issues that you will discuss during the forum.

# *Session 1 – My Transportation Routine Today*

## History of Transportation

The way that people move around has changed over time. The most basic form of transportation is walking. We could even consider shoes as the first type of transportation "technology." Horse-drawn carriages were the first examples of public transportation and those systems later evolved with the invention of electric cable cars, and subway and bus systems. Alongside these public transportation methods, people have traveled individually using bicycles and automobiles (along with motorcycles, horses, camels, skateboards, etc.).

Taxi cabs were introduced in the late 1890s as a service that could be arranged in advance or hailed on the street. Other ridesourcing services, meaning the ability to call for rides on demand, evolved from taxis. These services first started with companies that coordinated rides over the phone. The invention of apps that use the internet and smartphones have dramatically increased the popularity of ridesourcing services. As new technologies are introduced, some transportation methods, such as the use of horses, have faded into the background; many other transportation technologies, however, have existed alongside one another, offering individuals many ways to get around.




Wheel image created by Aline Escovar from Noun Project. Carriage image created by Gregory Montigny from Noun Project. Subway by Matthieu Mercier from the Noun Project.

**Figure 1.1:** *Timeline of transportation highlights. (Source: Information adapted from sources in Session 1 References)*

## Driverless Mobility

Driving is a challenging task. Drivers need to process many different pieces of information about road signals, other vehicles, cyclists, pedestrians, animals in the roadway, and weather conditions all at once. Plus there are additional distractions such as listening to music, talking to other passengers, and adjusting various controls.

To make driving easier, and therefore safer, car manufacturers have introduced Advanced Driver Assistance Systems (ADAS). ADAS systems include lane-departure and blind-spot warnings and adaptive cruise control; these are forms of automation. While these systems currently supplement human driving, many car manufacturers and technology companies are working toward full vehicle automation, eventually removing the need for a driver completely. This could lead to a future of driverless mobility, where vehicles like cars, buses, taxis, and trucks are controlled by computers instead of human drivers.

**Figure 1.2:** *Designers work on General Motors'* Futurama *exhibit. (Source: New York Public Library)*

The idea of driverless mobility is not new. For the 1939 World's Fair, General Motors created a 35,738 square foot diorama of a futuristic city with streets full of motorcars, trucks, buses, and taxi cabs called "Futurama." The model included sprawling highway systems with cars that used radio signals to maintain a safe distance. In the 1950s, General Motors shared a promotional movie of a car controlled by radio.

**Figure 1.3:** *NAHSC researchers demonstrate "no hands" highway driving. (Source: National Automated Highway Systems Consortium)*

In the 1960s, Ohio State University conducted research and developed electronic roadways that could provide remote input to a driverless car. At the same time, there were debates going on about vehicle safety. These debates were spurred by the book *Unsafe at Any Speed: The Designed-In Dangers of the American Automobile* by Ralph Nader. Nader's book revealed that some car manufacturers were reluctant to spend money on improving safety by introducing safety features such as seat belts. The book helped lead to the creation of the US Department of Transportation (DOT).

The United States government has played an important role in developing driverless mobility technology. In the late 1990s, DOT sponsored a research project called the National Automated Highway Systems Consortium (NAHSC). The goal of the project was to create an example of an automated highway system that could help improve efficiency and safety. The project created ideas for an automated highway system and conducted a demonstration in 1997. DOT ended the project in 1998.

Another big government push to develop driverless mobility technology came from the Defense Advanced Research Projects Agency (DARPA), which wanted to develop automated vehicles for military uses. DARPA hosted three competitions, called “Grand Challenges,” with a prize of $1-2 million for the team that developed the first automated vehicle that could navigate a set course. These challenges helped with the rapid development of the technology. Some technologies, such as LIDAR, existed before the challenges but were used for driverless mobility for the first time.

# *Session 2 – Automated* Systems, Trust, and Confidence*

## *Why Driverless Mobility?*

While driverless mobility systems arose from visions as diverse as more relaxed ways to travel and the ability to move in hostile or difficult conditions, additional issues are encouraging their development today.

Equity/Accessibility

One big area of discussion is increasing the equity and accessibility of transportation. Some companies working on these systems hope to open up new mobility options for those who have previously struggled to get around. Many individuals in the disability community, for instance, are excited by the idea that driverless mobility systems might create new transportation options for them. The Consortium for Citizens with Disabilities noted in a recent report, however, that the "promise and safety of [automated vehicles] will only be realized if the vehicles and the surrounding infrastructure are fully accessible, and the safety elements consider the needs of people with disabilities."

Driverless mobility systems may be able to increase not only who can use transportation, but also where mobility services exist. These systems are seen as a potential way to improve access to difficult-to-reach places. Rural areas, for example, typically have few, if any public transportation options. Many of these potential benefits depend on the ways in which these systems are developed. It is uncertain whether there is a business case for operating driverless systems in challenging rural environments. If some areas in cities become "driverless only," it could lead to segregation of people who can or cannot afford the technology.

Safety

One of the most widely discussed issues surrounding driverless mobility is safety. In 2017, 37,133 people were killed as a result of fatal car crashes in the United States. Nine percent of those fatal crashes were due to distracted driving, resulting from activities such as texting, eating, talking with other passengers, or adjusting radio or climate controls. Beyond distracted driving, drunk driving, road rage, and visibility issues with cyclists and pedestrians result in additional accidents and deaths every year. Overall, 94% of car crashes are due to human error. Many people hope that by putting driving in the hands of computers rather than humans, we could reduce the number of accidents and deaths.

Many activities in society have become automated, from the use of robots in manufacturing to motion-sensing lights. The goal of automating driving, however, is one of the most challenging. While the statistics about human-error caused accidents seem high, we're actually fairly good at driving: the number of car accidents that takes place is actually low compared to how much humans drive. The current US traffic safety statistics show that deadly crashes only occur about

* Automated refers to control by computer systems, involving software programming and use of algorithms.

once per hundred million miles of driving. Designing driverless mobility systems that can perform better than human drivers is a big challenge.

How many miles of driving would it take to show that driverless mobility systems really are safer than humans? Some studies estimate that these systems would have to be driven hundreds of millions of miles—or even hundreds of billions of miles—to show that they are reliably safer in terms of deaths and injuries.

Business Opportunities

Some companies are investing in the research and development of driverless mobility systems to support their existing services for transporting people or goods. Uber, a major ride-sharing company, is investing in the development of driverless vehicles. Amazon and Kroger, the grocery chain, are both exploring automated systems as a method for delivering goods; some of these involve vehicles that cannot carry passengers.


**Figure 2.1:** *Amazon delivery robot (Source: Wired.com)*

## *How do current systems work?*

Driverless mobility systems—including driverless cars, trucks, buses, and other motor vehicles—would be automated. This means that they would be controlled by software that would operate the vehicles and help them navigate. Current driverless mobility systems use multiple sensors to help them collect information from their surroundings.

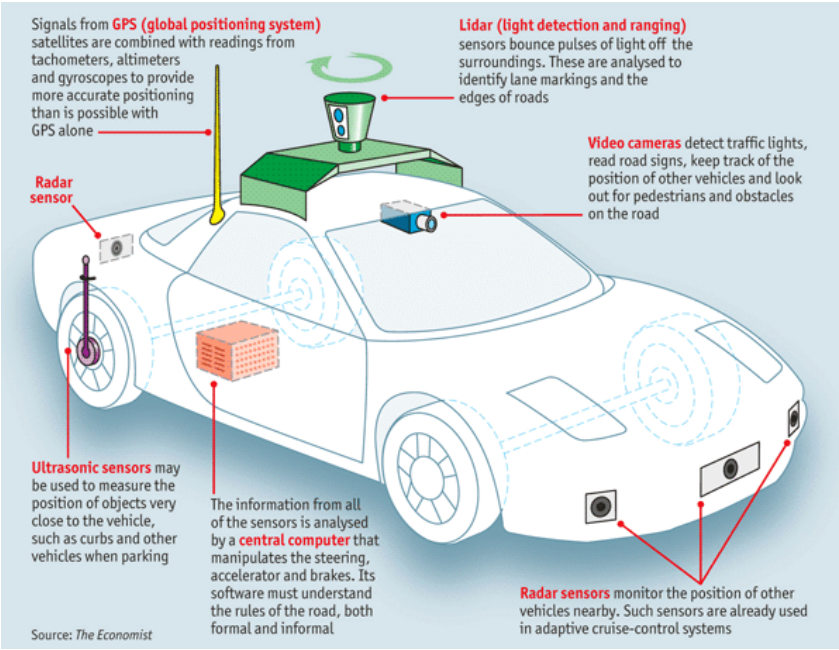



**Figure 2.2:** *Sample design of how current driverless vehicles work. (Source:* The Economist*)*

These systems are still in the early design stages. Just like the first bicycle or airplane designs were very different than the technologies we have today, future designs for driverless mobility could be very different than current designs. Keep in mind that Figure 2.2 shows *one* example of how some of the current driverless mobility systems work. Experts believe that future systems could look completely different, both in their physical design and how they work.

## *Technical Challenges*

The organizations working on developing driverless mobility systems have been improving the performance of their vehicles, but engineers and programmers are still working to address a number of technical challenges.

Environment Recognition

The video cameras used by some current designs of driverless vehicles capture and analyze images of other vehicles, pedestrians, and objects. These images are processed by the vehicle's central computer, which then reacts based on its programming. Though these programs are becoming increasingly advanced, there are concerns about whether these vehicles will be able to recognize the many different types of objects in motion on roads and to predict their behavior. Will the systems be able to account for nontraditional transport systems such as agriculture equipment or horses? Will they be able to recognize environmental hazards like flooded roads and respond appropriately? Will they be able to predict whether a child on the side of the road is simply standing there or is about to run into the path of the vehicle? Current driverless mobility systems are not able to do so.

**Figure 2.3:** *Examples of unusual forms of transportation and road hazards. (Source:* Schoettle 2019*)*

Sensor Reliability

Driverless mobility systems rely on their many sensors to operate. It is important to make sure that all of the sensors, as well as the software that processes information from the sensors, are working properly. Problems could arise if sensors malfunction, if weather inhibits their abilities, or if a software program interprets a sensor reading incorrectly, causing the vehicle to behave in a dangerous way. If the many sensors on driverless mobility systems are not cleaned and maintained properly, they might generate false readings and create dangerous situations. Developers would need to make sure these sensors are "failsafe." This could mean having backup sensors or other protections in place to make sure that false readings do not cause the system to react incorrectly or dangerously.

Human-System Interactions

Although the developers of driverless mobility systems are aware of the limitations of automated technology, users may not be. Studies have shown that people are not aware of the limitations of existing vehicle technologies like rearview cameras. Many people assume that these technologies are always working properly and tend to become overly reliant on them. This is a big problem if an automated system suddenly needs a human to take control during certain situations. If people do not pay attention and cannot take control of the vehicle in time, they might crash. This is the reason that some experts are pushing for "fully automated" systems that would never require a human to take over.

Cybersecurity

Cybersecurity presents an additional concern for the developers of driverless mobility systems. The systems must not only operate properly under normal driving conditions, but they must also be protected from bad actors. Hackers could potentially attack the computer systems in these vehicles to change the way the computers interpret signals from their sensors. They could, for instance, change the computer programming so that the vehicles interpret red lights as "go." If many driverless vehicles are connected via a wireless network, an attack on their communication network could cause chaos. From the annoyance of endless stop-and-go traffic to severe multi-car accidents, hacking presents a risk to driverless mobility systems.

Testing

To help driverless mobility systems learn how to react in different situations, the vehicles need to undergo a lot of testing. To match human capabilities, these vehicles need to be able to adapt to changing and unexpected conditions, such as various weather conditions, road conditions, traffic situations, and unpredictable human behavior. This testing can occur in a number of different ways. The systems are typically first tested using simulators. Like flight simulators used by pilots, these simulators test the computer programs in driverless systems. These tests help find any problems with how the systems respond to different situations and whether they correctly identify obstacles. Driverless vehicle simulators can present scenarios like traffic congestion, pedestrian interactions, and sensor configurations to test a driverless vehicle's computer programing.

Beyond simulations, driverless vehicles need to be tested on actual roads. This next phase of testing can occur on closed test tracks and on public roads called "testbeds." Test tracks feature road surfaces that are separate from public roads, like racecar tracks, but with various obstacles that can be added or removed to mimic different conditions. Testbeds are particular areas of cities or neighborhoods where driverless vehicles are allowed to operate on actual city streets.

Both Tempe and Chandler in Arizona have established themselves as testbeds for driverless technology.


**Figure 2.4:** *Left: Test track at Pennsylvania State University's Larson Transportation Institute (Source:* Larson Transportation Institute). *Right Test bed route for a driverless shuttle in Las Vegas (Source:* Hiott 2019, courtesy of AAA NCNU*).*

## *Current State of Driverless Mobility Technology*

Driverless mobility technology is still primarily in the testing and development phase, although a few companies are beginning to test operation of their vehicles with passengers.

In April 2017, Waymo, Google's driverless car company, launched its early rider program to allow members of the public to ride in their vehicles and provide feedback. Then, in December 2018, Waymo launched its commercial "driverless" vehicle service Waymo One. The service offers on-demand rides to approximately 400 residents in the Phoenix metropolitan area. These trips still involve a Waymo-trained driver who supervises the trip, so they are not completely driverless. These supervisors have had to take over in some situations, such as rainstorms and crowded parking lots.

Many vehicle manufacturers, such as Mercedes, BMW, Cadillac, Tesla, and Volvo, have begun to offer partially automated driving features on their high-end cars. These features include automatic car-following and lane tracking on well-marked highways in good weather conditions, but require continuous supervision by the driver.

Public transportation agencies have partnered with driverless mobility technology companies to offer transportation services. At present, these partnerships are using only low-speed driverless shuttles. For example, the European transit operating company Keolis is working with AAA, the Regional Transportation Commission of Southern Nevada, and the City of Las Vegas to


**Figure 2.5:** *Self-driving shuttle operating in Las Vegas (Source:* Hiott 2019, courtesy of AAA NCNU*)*

offer an 8-passenger driverless shuttle that runs a half-mile route in downtown Las Vegas.

### *Data Security, Management, and Privacy*

Driverless vehicle systems would collect significant amounts of data about their environments and passengers. Who controls these datasets and how they're managed are big questions. Some of this information would be used to operate the driverless systems. The many sensors on driverless vehicle systems generate information about road conditions, such as the location of potholes, that could be useful for local governments. Managing all these datasets and being able to extract useful information is a big challenge—a challenge for which some local governments feel unprepared.

Information about passengers and where they travel is valuable, especially to private companies like advertisers or consulting firms. These companies could sell data to a variety of groups. From businesses that want to sell to people based on their travel patterns, to employers, health insurers, or family members, who all want to know where people are going, interests may be either caring or intrusive.

The European Union recently created a data privacy regulation that reshapes the way that organizations handle data. The United States does not currently have similar regulations. Driverless mobility systems could affect how people feel about use of their data and bring up new concerns about privacy. Even if regulations limit data use, these systems could potentially be hacked by bad actors.

# *Session 3 – Future Automated Transportation Scenarios*

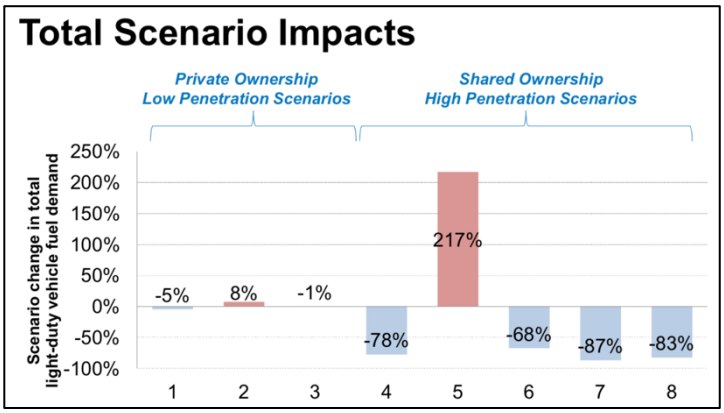
During the forum, we are going to explore some commonly discussed scenarios for how driverless mobility systems could develop. These scenarios include individual ownership of driverless vehicles, use of a ride-share model, and the development of a more automated public transportation system. While many people are excited about the potential benefits that driverless mobility systems might bring, experts recognize that there is a lot of uncertainty. Will these systems generate the benefits that people hope, or will they make certain problems worse, at least in the short term?

## *Areas of Uncertainty*

Environment

Some environmental advocates view driverless mobility systems as a way to increase environmental sustainability. Driverless mobility systems could have a positive effect on the environment if more people share rides, the vehicles use electricity created by renewable sources, and driving becomes more efficient by reducing stop-and-go traffic. However driverless mobility systems might increase travel by currently underserved populations (youth, disabled, or elderly people, for example). They might also encourage people to live further away from city centers, negatively impacting the environment.

According to a research study by the National Renewable Energy Laboratory, the uncertainty about these issues results in a wide possible range of impacts. For example, if people share rides and if driverless systems are electric, there could possibly be a nearly 90% fuel savings. On the other hand, if driverless vehicles cause more people to drive, live farther away, and the systems still use regular fuel, energy use could increase by more than 250%.




| Scenario Number | Name |
|---|---|
| 1 | Private Ownership, Fuel Savings Only |
| 2 | Private Ownership, Fuel Use Increase Only |
| 3 | Private Ownership, Combined Effects |
| 4 | Shared Vehicles, Fuel Savings Only |
| 5 | All Identified Potential Fuel Use Increases |
| 6 | Vehicle Electrification |
| 7 | All Identified Potential Fuel Savings |
| 8 | All Effects |

**Figure 3.1:** *A research study from the National Renewable Energy Laboratory shows that different scenarios might lead to different effects on total energy use (Source:* Brown, Repac & Gonder 2013).

Another environmental concern is the potential for urban sprawl, or the spreading out of urban areas. If driverless systems make commuting more pleasant, people may choose to live further from city centers. This would lead to the development of more land and potentially decrease sustainability. One hope with driverless mobility systems is that they will reduce the need for parking. The areas currently used for parking could then be redeveloped into parks, making cities greener. Alternatively, this space may just be redeveloped for buildings, which would not necessarily benefit the environment.

Economic Impacts

Potential job losses due to driverless mobility systems are of major concern. It is uncertain whether the development of driverless mobility systems would eliminate more jobs than it would create, and what types of jobs such systems might create. For instance, driverless mobility systems will require maintenance, although those positions may require specialized training beyond what is required of a traditional mechanic. New jobs might also be created. If a public transportation or ridesharing model becomes popular, new positions for vehicle fleet managers might be created.

These systems may also affect the trucking industry. In some communities, especially rural communities, trucking is one of a shrinking number of well-paying local jobs. Researchers at the University of Pennsylvania studied various scenarios in which different policies shape the effects of driverless mobility systems on trucking. In some of these scenarios, human drivers would work in partnership with driverless systems (Figure 3.2). The study suggests that governments and companies could work together to create proactive policies that might decrease the negative impacts of driverless systems on truck drivers. Such policies could help with job retraining and creating good-quality jobs, whether connected to trucking or not.

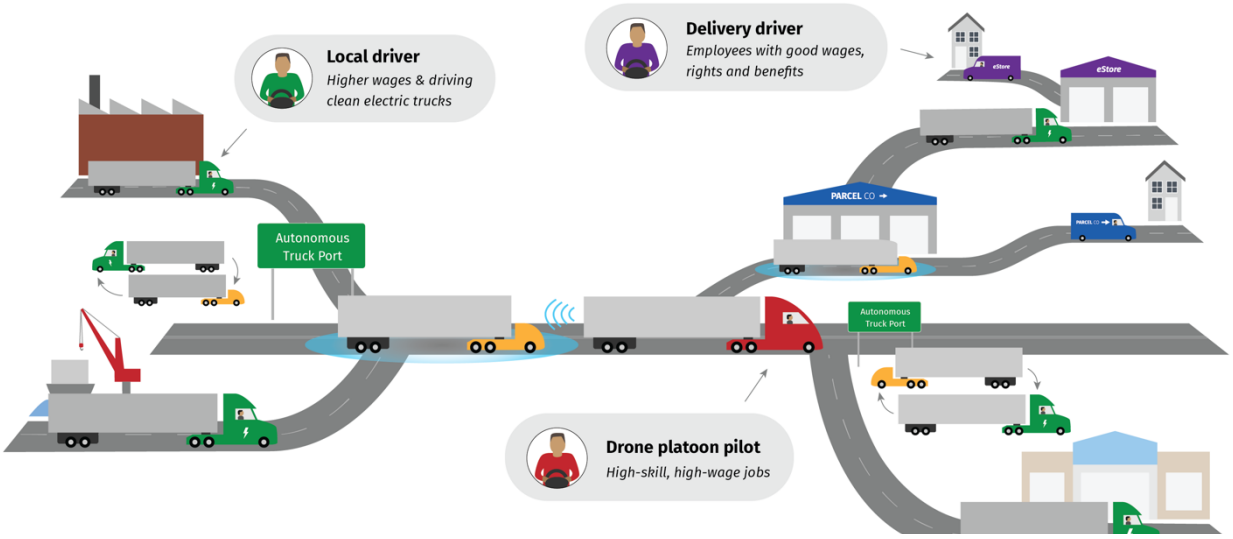



**Figure 3.2:** *Example of how automated trucks and human-driven trucks could work alongside one another* (Source: Viscelli 2018)

Costs

Driverless mobility systems might decrease transportation costs by eliminating the need for a driver, but the many high-tech sensors on the system could make the systems and their use very expensive. Some people are interested in the idea of an individual driverless vehicle, but the costs of these vehicles may exceed what the average person could afford. At present, driverless mobility companies are focusing more on creating fleets of driverless vehicles or shared driverless mobility systems that would be owned and operated by a private company or a public transportation agency.

Costs would also differ between shared and individual rides in driverless mobility systems. Sharing rides with others would likely be less expensive, just as it is now. Shared taxi rides and app-based ridesourcing services, however, are already more expensive than some people can afford. Driverless mobility systems could deepen the divide between those who can afford the services and those who cannot. If driverless mobility systems operate using smartphone apps, they may also exclude people who cannot afford smartphones.

Timing

Driverless mobility systems are not ready for full-scale deployment. Some of the benefits of these systems could only be achieved by replacing the majority of traditional vehicles with driverless mobility systems. It is very uncertain when, or if, this transition might even occur. The timing for this technology depends not only on when the technology itself could handle the complexities of driving, but also when and if people may be ready to use it.

# *Session 4 – Who Decides?*

Federal, State, and Local Government

Federal, state, and local governments play different roles in regulating transportation. The federal government controls the safety design and performance of vehicles; states regulate the human driver and operations; and local governments issue permits and manage parking and road infrastructure. The National Highway Traffic Safety Administration (NHTSA) issues Federal Motor Vehicle Safety Standards that are intended to influence how vehicles and their passengers are affected during a crash, as well as their ability to avoid crashes.

To address emerging driverless mobility systems, the Department of Transportation released three policy documents. Its most recent policy document, published in October 2018, is called *Preparing for the Future of Transportation: Automated Vehicle 3.0*. The report offers suggestions for how companies can consider and design safe testing and deployment of driverless systems.

Some state governments are beginning to draft legislation to regulate driverless mobility systems. The DOT report also includes recommendations for state governments for safe operation of these systems on roadways. Along with operations, some people feel there should be ethical standards for how driverless mobility systems are designed to operate. No uniform ethical standards for these systems currently exist.

Auto Industry and Technology Companies

Driverless mobility systems are being shaped by competing companies, with different visions for how these systems look and operate. Within the auto industry, there are different trade associations. One example is the Alliance of Automobile Manufacturers and the Association of Global Automakers, that connect companies to public policy. Some groups, such as the Self-Driving Coalition for Safer Streets and Partners for Automated Vehicle Education (PAVE), advocate for driverless mobility systems, either focusing on companies or on mixed groups of stakeholders.

Other organizations, such as SAE International, focus on professional and technical concerns of the auto industry and driverless mobility. Non-industry safety organizations, such as Advocates for Highway & Auto Safety, urge policymakers to make sure driverless mobility technology is safe. Beyond developing driverless mobility technology, individual companies and industry partnerships could play a role in shaping the policies that govern these systems.

With their advanced computers and sensors, driverless mobility systems have led to greater involvement of technology companies in an industry that is usually associated with heavy manufacturing. Tech companies like Uber and the Google spinoff Waymo are at the forefront of driverless mobility development despite little experience with building vehicles.

These tech companies and the auto industry are working to deal with challenging issues, such as privacy, data management, and cybersecurity, in addition to normal vehicle operation. Significant cultural differences exist between tech companies and the auto industry. The fast-paced tech industry is used to "moving fast and breaking things," with rapid cycles of development. Tech companies might involve customers in earlier stages of testing, which could be dangerous in a safety-critical system like a car. The automotive industry, by comparison, is used to strict safety standards and thorough testing prior to deployment.

Insurance

Currently, fault for accidents is placed on the vehicle operator, not the manufacturer, unless there is a mechanical problem with the vehicle. Driverless mobility systems, however, could change how insurance works. Insurance companies may offer discounts for policyholders who purchase vehicles with automated features if those can be proven to increase safety. Some European insurance companies give discounts for cars with driver-assistance features.

Insurance models will likely depend heavily on whether the systems operate via individual vehicle ownership or as fleets. If different states have different regulations, it may also be difficult for driverless system manufacturers to match all of the different standards. This could limit how far these systems could travel. Crashes with driverless mobility systems will likely look different from the crashes we have today; we may need to change the way that crash investigations are conducted. Fortunately, the many sensors on the mobility systems should make it easier to collect data that would provide information or clues about the crash causes (like a "black box" in airplanes).

Proactive vs. Reactive Regulation

Driverless mobility systems may look and operate differently from the cars and transportation systems we have now. Although many current driverless vehicle designs look similar to traditional cars, future designs could look completely different that vehicles today. How much should regulation control how safely these systems must function in order to protect the public? Consider, for instance, the difference between regulating the design of a bicycle versus that of an airplane. A problem with the design of a bicycle is unlikely to cause a large number of deaths at once, in contrast to a problem with an airplane.

Right now, the federal government is not regulating the design of driverless mobility systems. Instead, the *Automated Vehicle 3.0* report states that "Whenever possible, the Department [of Transportation] will support the development of voluntary, consensus-based technical standards and approaches that are flexible and adaptable over time." This is different that the European system of "pre-market certification" where systems must be formally tested before they are released to the public.

When problems do arise in driverless mobility systems, there are also different ways to handle them. People could sue companies for any loss or harm due to their use of a driverless mobility system after the harm has been suffered; this would, in turn, encourage companies to fix the problem. This idea of liability is a time-honored regulatory tool in the United States. It

encourages companies to create safe products and holds them accountable if they do not. The federal government could also issue regulations that dictate safety requirements for driverless mobility systems to try to prevent the harm in the first place, though some companies fear that this might stifle innovation.

**Publication**
**This information booklet was made to serve the specific purpose of informing participants in Our Driverless Futures: Community Forums on Automated Mobility. The publication is provided by the Consortium for Science, Policy & Outcomes to its partners and the forum participants. Read more about the project and the partners on http://themobilitydebate.net/.**

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Our Driverless Futures is part of a global project, "Tomorrow, Our Lives With Driverless Mobility," coordinated by Missions Publiques and the Consortium for Science, Policy & Outcomes. As part of the project, deliberations will be held in 17 cities across 9 countries in the North America, Europe, and Asia.

The development of the background information was made possible through a generous support from the Charles Koch Institute. Information does not represent the official views of the sponsor.

# *Appendix*

1. **Content from Timeline of Transportation Highlights graphic**
    - 3500 BC – First Wheeled Vehicles
        - Fixed wheels on carts are invented - the first wheeled vehicles in history.
        - Image: Graphic of a simple wheel. Graphic created by Aline Escovar from Noun Project.
    - 2000 BC – Horses
        - Horses are domesticated and used for transportation.
        - Image: Silhouette of a horse
    - 1662 – Public Transportation
        - Blaise Pascal invents the first public bus - horse-drawn, regular *route, schedule, and fare system.*
        - *Image: Silhouette of a calendar.*
    - 1790 – Modern Bicycles Invented
        - *Image: Silhouette of an individual riding a bicycle.*
    - Approximately 1820 - Omnibuses Popularized in U.S.
        - New York City introduces a system of omnibuses (small carriage that can carry up to 15 people) and horse carts, which became the model for many similar systems in other American cities.
        - Image: Silhouette of a carriage. Carriage graphic created by Gregory Montigny from Noun Project.
    - 1862 - First Gas Engine Automobile
        - Image: Silhouette of a car.
    - 1871 - Cable Car Invented
        - Commonly used in U.S. cities in the late 19th and early 20th centuries.
        - Image: Silhouette of a cable car.
    - 1887 – Subway System
        - First subway system in the U.S. is created in Boston. The concept is quickly picked up by other cities.
        - Image: Silhouette of a subway train. Subway graphic created by Matthieu Mercier from the Noun Project.
    - 1897 - Introduction of Taxi Cabs
        - First electric taxicab company introduced in New York.
        - Image: Silhouette of a taxi cab.
    - 1908 – Better Car Production
        - Henry Ford improves the assembly line for automobile manufacturing.
        - Image: Silhouette of a wrench and flathead screwdriver.
    - 2012 – App-based Ridesourcing
        - App designers in Silicon Valley launch mobile-based ridesourcing services.
        - Image: Silhouette of a cell phone.
    - Arrow pointing to the future with a question mark

2. **Content from "How current driverless vehicle systems work" graphic**
   - Signals from GPS (global positioning system) satellites are combined with readings from tachometers, altimeters and gyroscopes to provide more accurate positioning than is possible with GPS alone.
   - Radar sensors monitor the position of other vehicles nearby. Such sensors are already used in adaptive cruise-control systems.
   - Ultrasonic sensors may be used to measure the position of objects very close to the vehicle, such as curbs and other vehicles when parking
   - LIDAR (light detection and ranging) sensors bounce pulses of light off the surroundings. These are analyzed to identify lane marking and the edges of roads.
   - Video cameras detect traffic lights, read road signs, keep track of the position of other vehicles and look out for pedestrians and obstacles on the road.
   - The information from all of the sensors is analyzed by a central computer that manipulates the steering, accelerator and brakes. Its software must be understand the rules of the road, both formal and informal.

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