

7. Transportation Technology

Introduction

The North Central Texas Council of Governments recently established an Automated Transportation Program in response to the acceleration of the trend toward automation of highway transportation. Such automation may have a significant impact on the transportation system, providing both challenges and opportunities for improvement. This chapter describes the impetus behind the push for vehicle automation and related developments, outlines the emerging technologies, and discusses the possible consequences of automation. It then outlines policies designed to ensure vehicle automation will be deployed in a way that best serves North Central Texas.

Mobility 2045 Supported Goals

Improve the availability of transportation options for people and goods.

Support travel efficiency measures and system enhancements targeted at congestion reduction and management.

Ensure all communities are provided access to the regional transportation system and planning process.

Encourage livable communities which support sustainability and economic vitality.

Ensure adequate maintenance and enhance the safety and reliability of the existing transportation system.

Pursue long-term sustainable revenue sources to address regional transportation system needs.

Provide for timely project planning and implementation.

Develop cost-effective projects and programs aimed at reducing the costs associated with constructing, operating, and maintaining the regional transportation system.

Why Automation?

While the highway system delivers benefits to society, it has not advanced in any significant way for the past half century. Highway speeds remain about where they were in the past. Consistency has not improved regarding the time it takes to travel the same route from day to day, known as travel time reliability. Traffic congestion levels remain high despite billions of dollars in investment in new or expanded highways. While construction of the Interstates delivered substantial economic benefits because the Interstates offered a significantly improved form of highway travel, fewer economic gains are delivered by most highway investments today that add capacity to the Interstate System and similar expressways.

Transportation is the second-highest cost for many households. The average cost of owning and maintaining a vehicle is roughly \$10,000 per vehicle per year.¹ In auto-dependent areas such as North Central Texas, households may need multiple vehicles for household members to access jobs, healthcare, shopping, entertainment, and other needs. In low-income areas, transportation costs can eat up as much as a third of the household's income.² The costs associated with vehicle ownership make it difficult for some households to pay for other necessities or to invest in education or entrepreneurial efforts that will help the household advance up the economic ladder. The US Department of Transportation has found that North Central Texas has the highest percentage of households that own one or more vehicles of any major city in the United States.³ Some studies have indicated that this region also has relatively high levels of income inequality and low levels of

¹ US Bureau of Labor Statistics, 2017, *Economic News Release: Consumer Expenditures 2016*, <https://www.bls.gov/news.release/cesan.nro.htm>

² The University of Texas at Arlington Center for Transportation Equity, Decisions, & Dollars, 2017, *Equity Analysis of Dallas Mass Transit*, <https://ctedd.uta.edu/dart>

³ Federal Transit Administration, 2013, *Evaluating Transportation Equity: An Intermetropolitan Comparison of Regional Accessibility and Urban Form*, https://www.transit.dot.gov/sites/fta.dot.gov/files/FTA_Report_No._0066.pdf

social mobility, which may be a partial function of the high cost of transportation for low-income households.⁴

Some of the region's residents face constricted access to mobility due to their inability to drive because of their age or abilities. The number of these residents will grow between now and 2045 as the population of individuals age 65 and older increases.⁵

There are inefficiencies and costs associated with private vehicle ownership. Despite their high cost, vehicles sit idle for over 90 percent of the time.⁶ Vehicles are designed to carry multiple people, but carry a single person on most trips. This low occupancy, or vehicle load factor, is much lower than the load factors on bus, rail, and air transportation vehicles. The need for parking facilities to accommodate large numbers of vehicles requires the use of large amounts of land and other resources. As many as eight parking spaces per vehicle may be available.⁷ These spaces, like vehicles themselves, sit empty most of the time. In some urbanized areas, parking spaces and roads together may take up over 25 percent of the land, creating impervious surfaces that prevent rainfall from being absorbed, potentially increasing flooding.

Vehicle safety has improved over the long term, due largely to incremental improvements in vehicle design, such as air bags, and improved highway design, such as expressways with good pavement markings and generous space for lane merging. Despite this trend, vehicle crashes remain a public health problem and impact the economy. If current crash rates are extrapolated until 2045, the region can expect roughly 18,000 fatalities and 547,000 serious injuries from vehicle crashes between now and 2045.⁸ Future

crash, injury, and fatality totals will likely vary from these projections due to changes in population and transportation modes.

The costs of vehicle crashes are high. In a 2015 study, the National Highway Traffic Safety Administration estimated that crashes imposed direct costs of \$242 billion and indirect costs of \$594 billion on the US economy in 2010. Direct economic costs were equal to approximately 1.6 percent of US gross domestic product.⁹

In recent years, automated vehicle developers and transportation network companies have viewed these challenges as opportunities for technological and business innovation.

Vehicle Automation and Related Developments

Vehicle automation, vehicle electrification, and shared mobility are three interrelated developments that are driving innovation in the highway transportation sector. It is unclear at this time where these developments will go and their impact on the transportation system. North Central Texas should be prepared, however, for the possibility of significant changes between 2018 and 2045.

Vehicle Automation

Automation is well established in the transportation sector. Dallas Fort Worth International Airport, for example, has an automated people mover system. Buildings in the region have elevators that travel automatically. Much of the

⁴ Pew Research Center, 2015, *In greater Dallas area, segregation by income and race*, <http://www.pewresearch.org/fact-tank/2015/06/29/in-greater-dallas-area-segregation-by-income-and-race>; Simek, P., D Magazine, 2017, *Dallas' Poverty Problem Explained in a Single Map*, <https://www.dmagazine.com/frontburner/2017/03/dallas-poverty-problem-explained-in-a-single-map>; Nicholson, E., Dallas Observer, 2015, *Dallas Inequality in 22 Maps*, <http://www.dallasobserver.com/news/dallas-inequality-in-22-maps-7559829>; City of Dallas Human & Social Needs Committee, 2017, *November 6, 2017 [meeting recording]*, <http://dallastx.swagit.com/play/11062017-625>; Dallas Morning News, *Five ways the American Dream is broken for Dallas' working poor*, <https://www.dallasnews.com/opinion/editorials/2017/07/20/5-ways-american-dream-broken-dallas>

⁵ Office of the State Demographer, 2014, *Texas Population Projections, 2010 to 2050*, http://demographics.texas.gov/Resources/Publications/2014/2014-11_ProjectionBrief.pdf

⁶ Morris, D.Z., Fortune, 2016, *Today's Cars Are Parked 95% of the Time*, <http://fortune.com/2016/03/13/cars-parked-95-percent-of-time>; The Economist, 2017, *The perilous politics of parking*, <https://www.economist.com/news/leaders/21720281-average-car-moves-just-5-time-improve-cities-focus-other-95-perilous>

⁷ Chester, M., Horvath, A., & Madanat, S. 2010. Parking infrastructure: energy, emissions, and automobile life-cycle environmental accounting. *Environmental Research Letters*, (5)3, <http://iopscience.iop.org/article/10.1088/1748-9326/5/3/034001/meta>

⁸ Texas Department of Transportation, 2016, Crash Records Information System

⁹ National Highway Traffic Safety Administration, 2015, *The Economic and Societal Impact Of Motor Vehicle Crashes, 2010 (Revised)*, <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812013>

flight time for the commercial aircraft accessing Dallas Fort Worth and Love Field airports is done on autopilot.

There have been efforts to automate highway transportation for over a century. These efforts cover a spectrum that one end features “smart vehicles” that are designed to perform all of the driving functions themselves, commonly known as “autonomous vehicles”, and the other end of the

spectrum features “smart highways” that direct vehicle operation. For purposes of Mobility 2045, the term “automated vehicles” is used to cover the whole spectrum.

There are multiple levels of vehicle automation (**Exhibit 7-1**), as illustrated by this Society of Automotive Engineers classification that was recently adopted by the US Department of Transportation:¹⁰

Exhibit 7-1: Levels of Vehicle Automation

SAE Level	0	1	2	3	4	5
	No Automation	Driver Assistance	Partial Automation	Conditional Automation	High Automation	Full Automation
Description	Driver carries out all driving tasks.	Driver retains control but vehicle has some driving assistance features.	Vehicle has some automated features but driver must stay focused on driving tasks.	Driver does not have to focus on driving tasks, but must always be ready to take control if notified.	In certain situations, vehicle can carry out all driving tasks. Driver control is optional.	Vehicle can carry out all driving tasks. Driver control is optional.

In the past decade, automated vehicle developers have utilized improvements in computing power, sensors, and artificial intelligence to make strides toward rolling out vehicles with a high degree (Level 4) of automation. Auto manufacturers are developing and testing automated vehicles for street and highway use. These vehicles have the same general design as today’s vehicles but with additional sensors, computing power, and automated driving software. They are expected to be ready for widespread use by mobility fleet operators, such as transportation network companies, by the early 2020s.

Low-speed automated shuttles are another important category of automated vehicles. These shuttles typically accommodate about 10 people, travel at up to 25 miles an hour, and have a service range of roughly two miles. They are currently being deployed in closed campus-like environments. Test deployments of such vehicles are now occurring on low-speed public streets.

Automated vehicles are being actively developed around the world by auto manufacturers, tech companies, and universities. Governments at all levels throughout the world are supporting automated vehicle research and

development, recognizing the potential transportation and economic development benefits of such technology.

Most automated vehicle developers today are focused on developing autonomous vehicles, observing that it might take decades for the public sector to invest in the kind of roadside infrastructure necessary to allow semi-autonomous vehicles to run in full automation mode. Such developers have identified two key things that the public sector can do to support the deployment of automated vehicles:

- Implement high roadway maintenance standards, such as high-quality lane marking; this is essential in helping automated vehicles “see” roadway elements and navigate accordingly.

¹⁰ National Highway Traffic Safety Administration, 2017, *Automated Driving Systems 2.0: A Vision for Safety*, https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/documents/13069a-ads2.0_090617_v9a_tag.pdf

- Share the data governments have about roadways — especially road and lane closure information — to help support the safe operation of automated vehicles.

Within the next decade, and certainly by 2045, most of the vehicle fleet will have a direct high-speed connection to the internet. This connection will allow vehicles to share information about roadway conditions with each other. For example, a vehicle that encounters a lane closure can share that information with the mapping firms that provide real-time roadway information to automated vehicles. Such firms will update the maps for the automated vehicles approaching the lane closure.

The coming fifth generation (5G) of wireless communication will allow fast communication among vehicles and between vehicles and internet-based services and software. It will be important that highways and streets have robust wireless coverage in order to support automated vehicle operation. To be deployed, 5G requires the placement of a large number of small cells, which are devices installed to provide cellular access over a small geographic area. One of the key challenges for transportation agencies is figuring out how to ensure that private-sector 5G providers install sufficient fiber and small cells to create robust and reliable bandwidth along roadways to support large numbers of automated vehicles.

Vehicle Electrification

A global shift to electric vehicles appears to be under way. China and a number of European countries have committed to phasing out new internal combustion engine vehicles by 2045 or earlier. Reductions in the cost of batteries and other improvements have made electric vehicles more price- and performance-competitive with internal combustion engines.

Electric powertrains support a wide variety of vehicle types, including automated shuttles and personal vehicle “pods” that may someday be automated. Electric vehicles whose forms and functions fill the gap between electric bikes and the standard automobile may be developed. These vehicle

types will include the automated shuttles that are being deployed on a pilot program basis at sites around the world.



The city of Arlington operates the Milo autonomous vehicle during events in the Entertainment District.
Source: City of Arlington

Shared Mobility

Shared-mobility services including car sharing, ridesharing, and bike sharing platforms have emerged in the past decade and have impacted the transportation system. These services have attracted consumers with the services’ flexible and convenient mobility, powered by apps that handle ride hailing, payment, and navigation.

Shared-mobility services have proven popular with consumers, and the market is growing. Where today shared-mobility services in the region cover well under 5 percent of all trips, it is forecast that by 2030, approximately 30 percent of all trips in the region will be handled through shared-mobility services.¹¹

Developers around the world are working with these three elements — automation, vehicle electrification, and shared mobility — to advance major

¹¹ Morgan Stanley, 2016, *Shared Mobility on the Road of the Future*, <https://www.morganstanley.com/ideas/car-of-future-is-autonomous-electric-shared-mobility>; McKinsey & Company, 2017, *How shared mobility will change the automotive industry*, <https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/how-shared-mobility-will-change-the-automotive-industry>; Deloitte University Press, 2016, *The future of*

mobility: What’s next?, https://www2.deloitte.com/content/dam/insights/us/articles/3367_Future-of-mobility-whats-next/DUP_Future-of-mobility-whats-next.pdf; The Boston Consulting Group, 2017, *By 2030, 25% of Miles Driven in US Could Be in Shared Self-Driving Electric Cars*, <https://www.bcg.com/d/press/10april2017-future-autonomous-electric-vehicles-151076>

changes to the surface transportation system. Most automated vehicles are being developed on an electric vehicle platform. Shared-mobility services — not individual consumers — are likely to be the first big customers of automated vehicles. Unmanned electric vehicles in continuous operation deployed in fleets could offer mobility at a lower per-mile cost than today's privately-owned vehicle. Shared-mobility services, where multiple users ride in the vehicle at any one time, could drive down the per-mile cost even more.

According to this vision of the future, the cost of automated vehicle services would drop below the cost of operating a personal vehicle. This would lead people to shift to a model of mobility as a service. Rather than investing in an expensive capital asset on wheels that sits idle most of the time, many people would prefer to pay for just the amount of mobility they need. Just as people book and pay for only the amount of airline travel they need rather than owning their own jetliner, they would be able to do the same with their surface transportation, namely, consuming just the amount of vehicular mobility they need. The consumers' cost-driven preference for lower-cost automated vehicles would increase the demand for automated shared-mobility services and accelerate the transition to automated vehicles. Ultimately, more mobility would be consumed by more people at a lower per-mile cost and a greater level of safety than before.

There is a great deal of uncertainty associated with this popular vision of the future. Automated vehicle technology would need to improve, consumers would have to accept riding in shared automated vehicles, and automated vehicle fleet operators would have to be able to develop a sustainable business model.

Possible Impacts on Transportation System

A great deal of uncertainty is associated with automated vehicles. Despite progress, there is no assurance that automated vehicle technology will advance sufficiently to support pervasive Level 4 automation. There is no assurance that consumers will accept automated vehicles or embrace a shift from private vehicle ownership to mobility as a service. Likewise, there is no assurance that consumers will embrace multi-occupant vehicle shared-mobility services that, with automation and electrification, can greatly improve the performance of the highway transportation system.

Just as there is no consensus about the timing and extent of the widespread adoption of vehicle automation, there is no consensus about the impact of automated vehicles should they be introduced successfully and embraced by consumers. Some of the anticipated impacts include:

- An increase in demand for mobility might result if automated vehicles can reduce the per-mile cost of mobility and eliminate the age and other requirements of a driver's license. As noted previously, this effect could be mitigated, if not counteracted entirely, by shared-mobility vehicles carrying multiple occupants.
- The land-use impacts of automated vehicles may be significant depending on whether automated vehicles are deployed mainly in fleets or in the current model of private vehicle ownership. Possible impacts might include:
 - Reduced amount of land required to accommodate vehicle parking, freeing up the land for other uses.
 - Increased demand for housing in outlying areas by people who are willing to tolerate long commutes because they can do work while traveling in automated vehicles.
 - Increased demand for housing in higher density urbanized areas as people opt to end or limit their private vehicle ownership in favor of pay-as-you go mobility through automated vehicle fleets.
 - Increased clustering of housing and businesses because of the reduced need for surface parking.
- Building design may change because electric vehicles are able to operate inside enclosed facilities, allowing for in-building pick-up and drop-off zones.
- Roadway design may change to accommodate automated vehicles. These changes might include:
 - Narrower lanes.
 - Heavier investment in infrastructure, such as fiber and small cells, that supports robust wireless communication solutions, such as 5G, that enable automated vehicles.
 - Road markings and other visual features to help automated vehicles better read the roadway path.
 - Electronic beacons to help guide automated vehicles and help reduce the distance between vehicles, increasing roadway capacity.
 - Reduced signage and dynamic message signs targeted at human drivers.

- Dedicated lanes for special uses, such as automated vehicles or truck platooning, when trucks communicate with each other to coordinate their movements.
- Accommodation of new vehicle types that emerge from the intersection of vehicle automation and electrification, such as smaller vehicles that require less lane width.
- Gas tax revenues could drop faster than otherwise projected if automated vehicles developed primarily on an electric powertrain platform capture a significant share of trips. This could necessitate a fee associated with vehicle miles traveled or other tax to provide revenue to fund the building, maintenance, and rehabilitation of roads.
- Highway operations and planning could change as a result of the extensive data that vehicles will gather and disseminate in real time. Such data, which will include video and Lidar, will allow emergency responders to assess the nature and severity of an incident before deploying emergency resources, potentially improving the quality of the response and reducing the costs associated with emergency response. Such data will be mined to identify roadway trouble spots, such as areas where vehicles are swerving or braking suddenly, that can be targeted for investments that improve safety. Such data can also assess the efficacy of roadway investments.

The impact of automated vehicles on travel behavior is not known at this time. It is unknown whether:

- Automated vehicle technology will mature sufficiently to be widely deployed.
- Consumers will accept automated vehicle technology even if that technology matures sufficiently to allow for widespread deployment.
- The private vehicle ownership model will continue with the arrival of automated vehicles or whether consumers will embrace a mobility-as-a-service model where they pay for the mobility they need from mobility services providers rather than own their own vehicle.
- The evolution of vehicles to become places where drivers and other occupants can work, shop, and consume entertainment while en route will change the consumer tolerance for trips lengths.

These and other uncertainties make it impossible to confidently predict the deployment and impact of automated vehicles. What is certain is that after a stable operating model for the past half century, the highway transportation sector is being impacted by the same advances in digital technology that have

transformed other sectors of our economy and society, such as retail, banking, entertainment, and communications.

Financial Summary

By continuing to monitor developments in the transportation sector and engaging with the public and regional partners, the North Central Texas Council of Governments will plan for and adapt to the three related developments that are advancing transportation technology and service models: automation, electrification, and shared mobility.

While much of this work will take place in the ordinary course of designing, building, and operating roadways and other parts of our transportation system, in April 2017, the Regional Transportation Council approved approximately \$2.5 million to fund projects to advance automated vehicle technology and prepare the region for automated vehicles. These projects include:

- Two pilot programs for low-speed automated vehicles.
- Use of IH 30 between Dallas and Fort Worth as a test corridor for high-speed automated vehicles.
- Further development of the data infrastructure to support automated vehicles.
- Support for the next-generation people mover system using automated vehicle technology.

Policies

The developers of automated vehicles have identified two things that roadway operators can do to optimize the operations and safety of automated vehicles. First, well maintained roads with good quality lane striping are key to successful operations. Second, by sharing accurate information about changes to roadway conditions as a result of things such as lane closures for construction work, roadway operators can help improve the operation of automated vehicles. It is noteworthy that the things that will advance the successful operation of automated vehicles will also improve the operation and safety of human-driven vehicles. The transportation technology policies that advance these objectives are as follows:

TT3-001: Transportation agencies in the region will make data about their systems accessible using open data best practices in order to support

automated vehicle operations and optimize the operation of travel navigation, mobility-as-a-service payment, and other transportation services in use today and in the future.

TT3-002: Priority will be given to two-way data sharing arrangements under which the recipient of transportation data from public agencies in the region share their transportation data with public entities in the region.

TT3-003: Transportation agencies will do a cost/benefit analysis of data sharing as an alternative to the installation, operation, and maintenance of hardware solutions before proceeding with hardware solutions.

TT3-004: The region will support the installation and operation of reliable and robust wireless communications in and around transportation facilities.

TT3-005: The region will explore advances in technology as a way to preserve transportation corridors and utilize them most effectively.

TT3-006: The region supports the testing and deployment of automated vehicles that meet applicable safety and legal requirements.

TT3-007: Maintaining existing roadways at a level that supports the effective and safe operation of automated (and human driven) vehicles will be accomplished before investing in the construction of new roadways that add to the inventory of roadways the region must maintain.

TT3-008: The region will support efforts to ameliorate the impact of increased demand for mobility as a result of automated vehicles by supporting efforts to increase average vehicle occupancy by transportation network companies and other transportation suppliers and through demand management tools such as TryParkingIt.

TT3-009: In making planning and investment decisions concerning roadways, transportation agencies will do a cost/benefit analysis of using automated vehicle technology and demand management tools as an alternative to building additional lanes to increase roadway capacity.

TT3-010: Automated vehicles must be deployed in a manner consistent with Mobility 2045 goals of providing the public with a transportation system that offers the public more travel options and enhances the safety of other roadway users such as bicyclists and pedestrians.

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