TTTF

TEXAS TECHNOLOGY
TASK FORCE

# 2022 TECH UTILIZATION PLAN

TTTF

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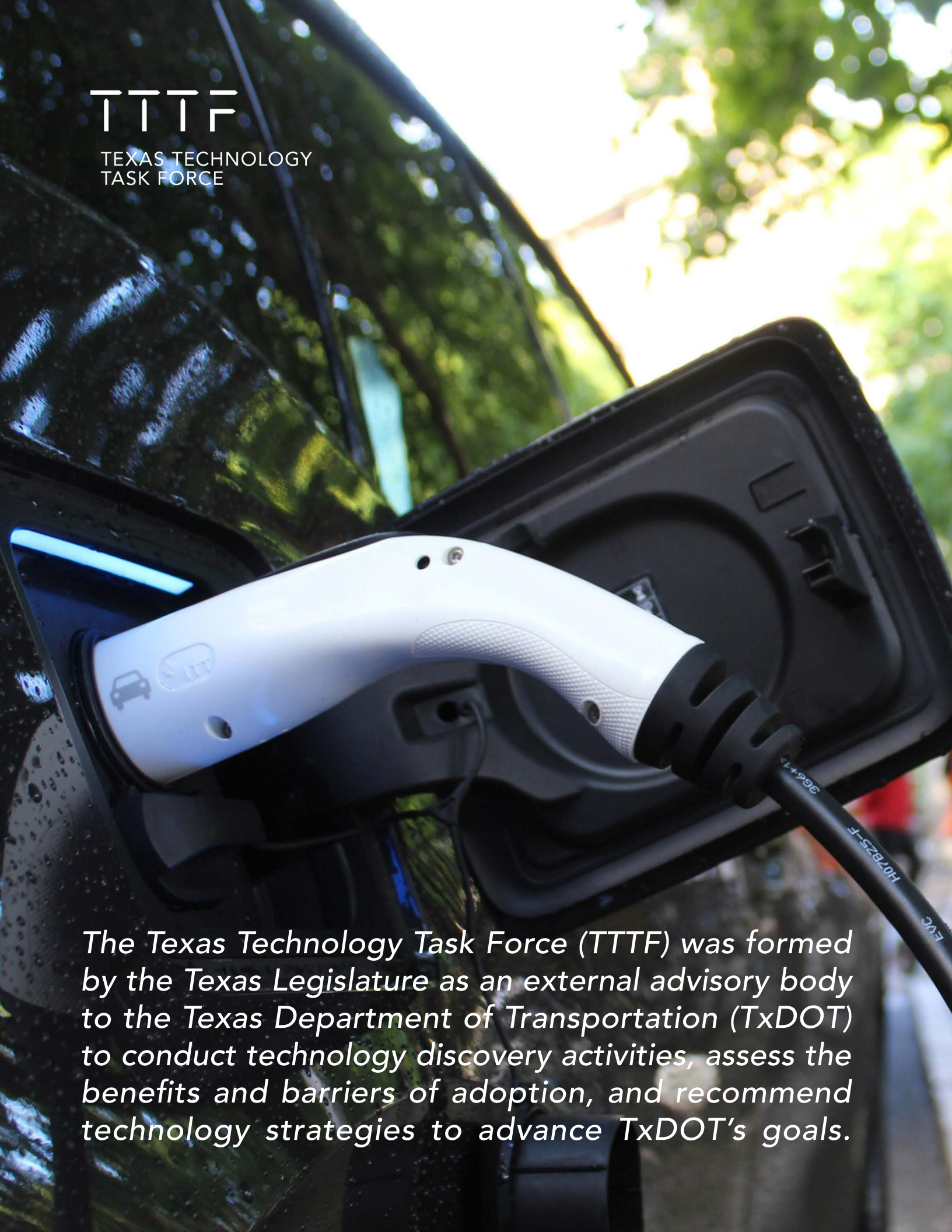
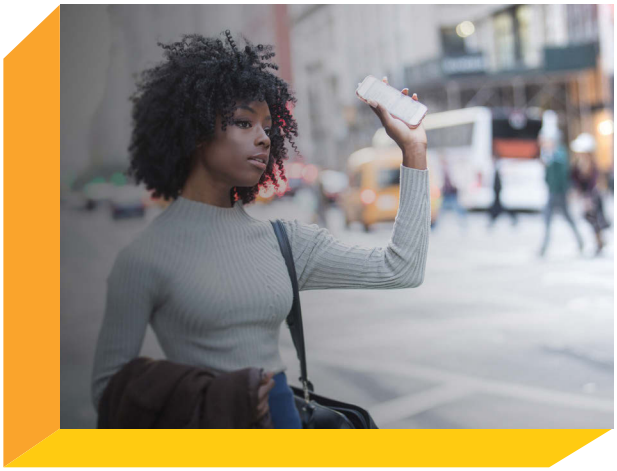


*The Texas Technology Task Force (TTTF) was formed by the Texas Legislature as an external advisory body to the Texas Department of Transportation (TxDOT) to conduct technology discovery activities, assess the benefits and barriers of adoption, and recommend technology strategies to advance TxDOT's goals.*

# AT A GLANCE.

*AUTOMATED VEHICLES, CONNECTED VEHICLES, ELECTRIC VEHICLES, UNMANNED AERIAL SYSTEMS, BIG & OPEN DATA, MOBILITY-AS-A-SERVICE*




electric
drive

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# *Introduction: Technology Utilization Plan*

# Update to the Technology Utilization Plan

The Texas Technology Task Force (T3F) provides guidance to The Texas Department of Transportation on the discovery, planning, and utilization of emerging transportation technologies such as connected and automated vehicles (CAVs), big data, artificial intelligence, telecommunications, virtual reality, and more. The T3F delivers a variety of planning and informational documents, including the Technology Utilization Plan (TUP). The first iteration of the TUP was completed in 2019 with information on the plan development process, priority technology assessments, application case studies, and recommendations for advancing technology. An update to key sections is provided.

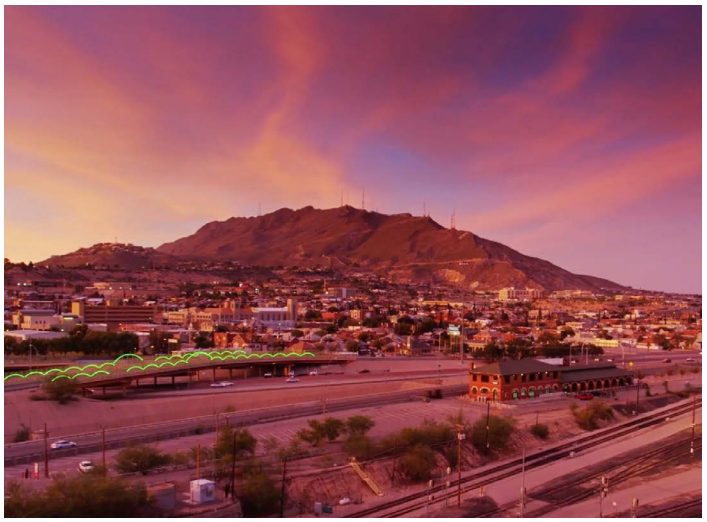
Since the TUP completion, many major events and influences have changed the landscape of Texas, including population growth, demographic composition, urbanization, impacts on travel from COVID-19, freight and supply chain disruptions, federal policy and funding opportunities, and severe weather events. Details of these events and influences follow.

## Changing Texas at Landscape

Texas is experiencing rapid population growth, with projections showing continued high growth well into the coming decades. Urbanization, aging, and diversification are three main trends associated with growth that are identified as having the potential to significantly impact the state's transportation system. All three trends present unique challenges and opportunities, raising questions for transportation and innovative investment planning.

When assessing the extent of urbanization across the state, it is important to look first at one key indicator: population projection. The Texas Demographic Center projects that if the population continues to grow at rates similar to the present, the total population for the state could grow from 29.1 million, as of 2019, to 47.4 million by 2050[1]. There are regional differences to where this growth has occurred. A significant majority of Texas residents live along or east of the I-35 corridor, with growth concentrated in the Texas Triangle that includes the major urban centers of Dallas-Fort Worth, Austin, San Antonio, and Houston, as well as adjacent suburbs and smaller cities with I-35, I-10, and I-45 as approximate borders.

Beyond the Texas Triangle, growth is still occurring but in a less concentrated and less rapid manner. The urban and suburban areas of West Texas and the Lower Rio Grande Valley are experiencing moderate levels of growth, with cities such as El Paso, Lubbock, Odessa, Midland, and McAllen seeing lower but still significant population growth. Population drivers for these regions differ from those of the Texas Triangle and may include specific economic draws like the oil industry and jobs associated with border control or familial ties and more affordable housing options. It is important to note that while a large portion of the state is experiencing explosive growth there are areas in Texas where population is declining. Population decline is largely occurring in areas outside of the Texas Triangle, including mostly rural communities throughout the state. These communities face their own unique challenges including safety, enabling economic development through public infrastructure and accessibility to opportunities.



During the last decade, California has been the state contributing the most domestic migrants to Texas, followed by Illinois and New York[2]. Demographics reports show that many people migrating to Texas are highly educated and part of the skilled labor force; they are moving to Texas's urban areas, drawn to white-collar jobs in cities. Other factors beyond employment are drawing people to the state: quality of life, affordability (although this may fluctuate by region and origin of new resident), warmer climate, and diversity have been cited as other contributing factors[3]. Regardless of reason, migration to Texas cities is projected to continue into the future, indicating additional strain on the transportation system if they are not accounted for.

In addition to urbanization, the percentage share of the older adult population is another key demographic trend to monitor. In coming years, the United States will experience a mass wave of retirements as the sizable Baby Boomer generation (the age cohort born between 1946–1964) age out of the workforce. This is a concern both nationally and locally because cities and regions will need to grapple with the changing and oftentimes increasing needs of an older population. The Texas Demographic Center projects that by 2030 almost 20 percent of the state's population will consist of the aging Baby Boomer generation[4]. Texas is unique in this consideration because, compared to other states, its population relatively young. But due to the sheer population size, the state must prepare for the emerging needs of an aging population just as urgently as other states. In Texas population aging is occurring in both urban and rural areas, which presents additional complexity due to the differing levels of resources available to rural versus urban residents. Older adults typically require transportation or disability services and often have additional care needs when compared to younger generations. This indicates a shift in how resources must be allocated as the state's population continues to age.

Increasing diversity is another key demographic trend to track. From 2010 to 2020 95 percent of Texas's population growth could be attributed to persons of color, with the Hispanic ethnic population comprising of 49.5 percent of the total[5]. Again, Texas is seeing more diverse populations concentrate in cities and adjacent suburbs across the state, following similar patterns to areas experiencing rapid urbanization. The major cities in the Texas Triangle, El Paso, and cities in the Lower Rio Grande Valley are hubs for these diverse populations. The transportation needs for these new residents might be differ significantly those of the populations historically established in those areas. For example, a new resident moving to Texas might have different mobility preferences to those that are served by the existing transportation system. This conflict in preferences will be a challenge for the state moving forward when it comes to designing a transportation system that equitably supports all users.

Trends in urbanization, aging, and diversification, as highlighted above, are not exhaustive to the population shifts that Texas is experiencing. Other relevant trends include an increasing share of the youth population and changing levels in homeownership rates to name a few; however, the three trends explred here have been highlighted as some of the most impactful due to their immediate and pressing influence on the transportation system. Issues of traffic congestion, shifting mobility needs, and equitable access are key concerns. A better understanding of the current and future population demographics for the state will assist TxDOT in moving forward with appropriate plans and projects that cater to the most important component of Texas' transportation system—its users.

## COVID-19 Impacts on Transportation and Travel

The impacts of COVID-19 and the stay-at-home order may have left a lasting impact on travel patterns and the transportation system. Observed impacts are summarized below.

Post-COVID traffic patterns have been inconsistent and vary based on income and population. Traffic data reveals that the return to in-person work is uneven with increasing pressure on lower-income residents compared to those in higher-income brackets. Lower-income workers are more likely to work in service and labor jobs where remote work is not an option. A new TomTom traffic study reports that although congestion levels went up slightly in 2021 when compared to the year before, they remained lower than in previous years[6]. In Austin, data shows that highway traffic is back to pre-pandemic levels but arterials are still 15 percent lower than pre-pandemic volumes.

With less traffic on the roadways there is a trend toward higher speeds, more careless driving, and an increase in traffic fatalities. More than 4,480 people were killed on Texas roads in 2021, making it the second deadliest year since TxDOT began tracking fatalities (1940); the most deadly year, 1981, saw 4,701 fatalities. The increase reflects a deadly trend nationwide: an estimated 20,160 people died in motor vehicle crashes in the first half of 2021, up 18.4 percent over 2020. In Texas, traffic fatalities were up 15 percent from 2020–2021[7].

Anecdotal micromobility and transit data shows that pedestrian and bike usage increased in Austin while transit ridership decreased. With the onset of the pandemic,

there was concern about surface contact and viral transmission among transit riders, leading to reduced usage. Simultaneously, the majority of Austin transit users are dependent on it for access to jobs, education, and other uses. They therefore had to turn to alternate resources for mobility, which accounts for the rise in micromobility modes like scooters and electric bikes. The rise in micromobility use during the pandemic followed an initial decline in March and April 2020, when companies pulled some devices as a result of uncertainty about surface contact issues. Currently transit and mobility services are still rebounding from the pandemic.

Finally, stay-at-home orders underscored the need for reliable internet connectivity across all Texas communities. With more rural schools than any other state, Texas realized how critical high-speed broadband is for educational access. Work and medical access were (and still are) so reliant upon connectivity that the Texas Legislature set up an office to expand access to and affordability of high-speed broadband first leveraging funds from the $500 million in federal pandemic relief.

## Freight and Supply Chain Disruptions

The COVID-19 pandemic severely disrupted many supply chains worldwide, and the

impact on Texas became especially evident at the Texas-Mexico border. Automotive, defense/aerospace, electronics, personal care product and semiconductor industry closures in Mexico caused major disruptions in the flow of commodities across the border into the United States. After years of steady growth, imports by truck declined to almost zero at the El Paso, Hidalgo, and Laredo ports of entry in spring 2020 before beginning to rebound in summer 2020. Owing significantly to the decrease in cross-border traffic, wait times for trucks decreased substantially when compared to 2019 before also rebounding in summer 2020. Wait times for privately owned vehicles dropped as well during the pandemic, due largely to restrictions imposed on nonessential travel.[8]

With its 19.4 percent share of US exports, Texas's economy greatly depends on international trade and stable supply chains. State exports have largely recovered from the pandemic and have increased more than 10 percent from 2019.[9] Leading the way is a surge in oil, gas, and petrochemical exports to China and other countries, up 41 percent since 2019. With especially robust trade in intermediate goods, Mexico remains the state's largest export destination. Texas business leaders are reporting much stronger demand for goods and services this year, but supply chain issues remain a concern.

As consumers turned to online shopping, cargo ships carrying goods struggled to keep pace with demand and caused significant backups at the country's biggest ports. A record number of containers have arrived at the Port of Houston, for example, but many were empty on their return trips, creating significant lost revenue. The Port of Houston, the nation's largest port, said the increase in imports have been positive, and the port saw its biggest third quarter in 2021, mainly driven by imports. The port did not experience the backups and delays like other ports due to consistent investment made in infrastructure and operations in preceding years.[10]

## Federal Policy & Funding

The Biden Administration brought new priorities and programs that will have a significant impact on many areas of transportation. Notable bipartisan efforts include an infrastructure package that contains various elements of Biden's American Jobs Plan (AJP), the Drinking Water and Wastewater Infrastructure Act, the Surface Transportation Reauthorization Act, the Surface Transportation Investment Act, and the Energy Infrastructure Act. Along with the Bipartisan Infrastructure Law, the legislation ultimately evolved into the $1.2 trillion Infrastructure Investment and Jobs Act (IIJA), which the senate passed in a 69-30 vote in early August 2021 and the House passed November 2021 in a 228-206 vote. The IIJA focus is repairing and rebuilding roads and bridges with a focus on climate change mitigation, resilience, equity, and safety through discretionary funding programs. The IIJA will improve accessibility and reduce green-

house emissions through the largest investment in public transit in US history and it will provide funding and coordination to build a national network of electric vehicle (EV) chargers to facilitate the adoption of EVs.

The Joint Office of Energy and Transportation was created through the IIJA to facilitate collaboration between the US Department of Energy and the US Department of Transportation. The office is tasked with aligning resources and expertise across the two departments toward joint, leveraged outcomes, and will be a critical component in the implementation of the IIJA, providing support and expertise to a multitude of programs that will deploy a network of EV chargers, zero-emission fueling infrastructure, and zero-emission transit and school buses. The scope of the Joint Office will evolve as directed by both departments.

## Extreme Weather Events in Texas

A severe weather event in February 2021, known as Winter Storm Uri, brough significant snow and ice accumulation and statewide power outages in February 2021. The storm contributed to at least 210 deaths, severe supply chain disruptions; the Federal Reserve Bank of Dallas estimates the state's storm-related financial toll could total as much as $130 billion in damages and economic losses. Following the power outages, the reliability of the Texas energy grid has been called into question and especially in its capacity to support electric vehicles. As a future with greater EV market adoption is considered, measures must be taken to ensure power generation and transmission can support EV demands. In addition, due in part to the ice-covered roadways and railways, supply chains were severely interrupted in Texas. The transport of critical goods such as medical supplies, water, and food was extremely challenging, and the storm underscored the need for public agency and industry collaboration in preparedness for severe weather events in the future.


In 2022, as Texas is enduring record summer heat and the energy grid the system is being pushed to near-emergency conditions, authorities are asking for residents to take measures to conserve energy to prevent blackouts. Of particular relevance to the discussion of the power grid on transportation, Tesla has asked its customers in Texas to avoid charging their electric vehicles during peak times in order to prevent stressing the state's power grid.[11]

## Conclusion

Texas is a dynamic and diverse state that continues to change and experience the impacts of growth and major weather events. As the nature of the state's challenges are ever-changing, the T3F is committed to working alongside TxDOT and industry experts to discover new technologies, assess their readiness, identify open questions, and craft recommendations for their advancement. The remainder of the updates to the TUP focus on the six priority technologies:

1. Automated Vehicles
2. Connected Vehicles
3. Electric Vehicles
4. Unmanned Aerial Systems
5. Big Data
6. Mobiilty-as-a-Service

# Texas Technology Task Force

# Texas Technology Task Force

The Texas Technology Task Force was formed as an external advisory body to the Texas Department of Transportation (TxDOT) to conduct technology discovery activities, to monitor existing technologies, and bring awareness about new ones. The following summarizes the Task Force's origins, mission, activities, and relationship to other innovation efforts within TxDOT.

## Task Force Origin

The 83rd Texas Legislature (2013) issued a mandate to TxDOT to establish a technology task force to monitor and advise on emerging transportation technologies. The Texas Technology Task Force formed following this mandate with a deliberate composition of subject matter experts across industry, research institutions, and public agencies with extensive knowledge in vehicle automation, telecommunications, big data, innovative funding and partnerships, transit, freight, long-range and strategic planning, and additional areas of expertise. Task Force membership is dynamic; although it has remained relatively unchanged, it undergoes periodic review to ensure that the right mix of expertise is included to capture perspectives on new technologies and innovative processes.

## Mission & Activities

The Task Force has designed its activities to advance the mission of transformational technology discovery, stakeholder engagement, coordination and planning with other state agencies, and developing strategic recommendations for technology advancement. The Task Force activities are planned around its organizing principles of People, Portfolio, Plans, and Process. Each of these principles and corresponding activities is described below.

## People

The Task Force activities provide a platform to engage various stakeholder groups on technology awareness and planning. These stakeholder groups include the following:

***Transportation leadership and policymakers*** - Texas Transportation Commission, TxDOT Administration, elected official and their staff, Governor's Office.

***TxDOT staff*** - practitioners from across all TxDOT divisions, including but not limited to freight, traffic, strategic planning, information management, long-range planning, legislative affairs, fleet management, and research & technology implementation.

***Public agencies*** - other state agencies such as the Department of Motor Vehicles, Department of Public Safety, the Texas Department of Insurance, Texas Commission on Environmental Quality, Public Utilities Commission, local public agencies, metropolitan planning organizations, transit authorities, federal agencies, etc.

***Industry experts*** - subject matter experts from automated driving systems, telecommunications, information & technology, data management and mining, transportation network companies (TNCs), freight and logistics, etc.

## Portfolio

The Task Force developed and maintains the Emerging Technology Portfolio as a tool for tracking new and maturing technologies that are expected to be transformative to transportation. The Portfolio is a dynamic list that group technologies into the following technologies: next-generation vehicles, infrastructure & construction, materials & additive manufacturing, information & communications, service-based

platforms, and other technologies. A full list of technologies in the portfolio is shown in Figure 1.

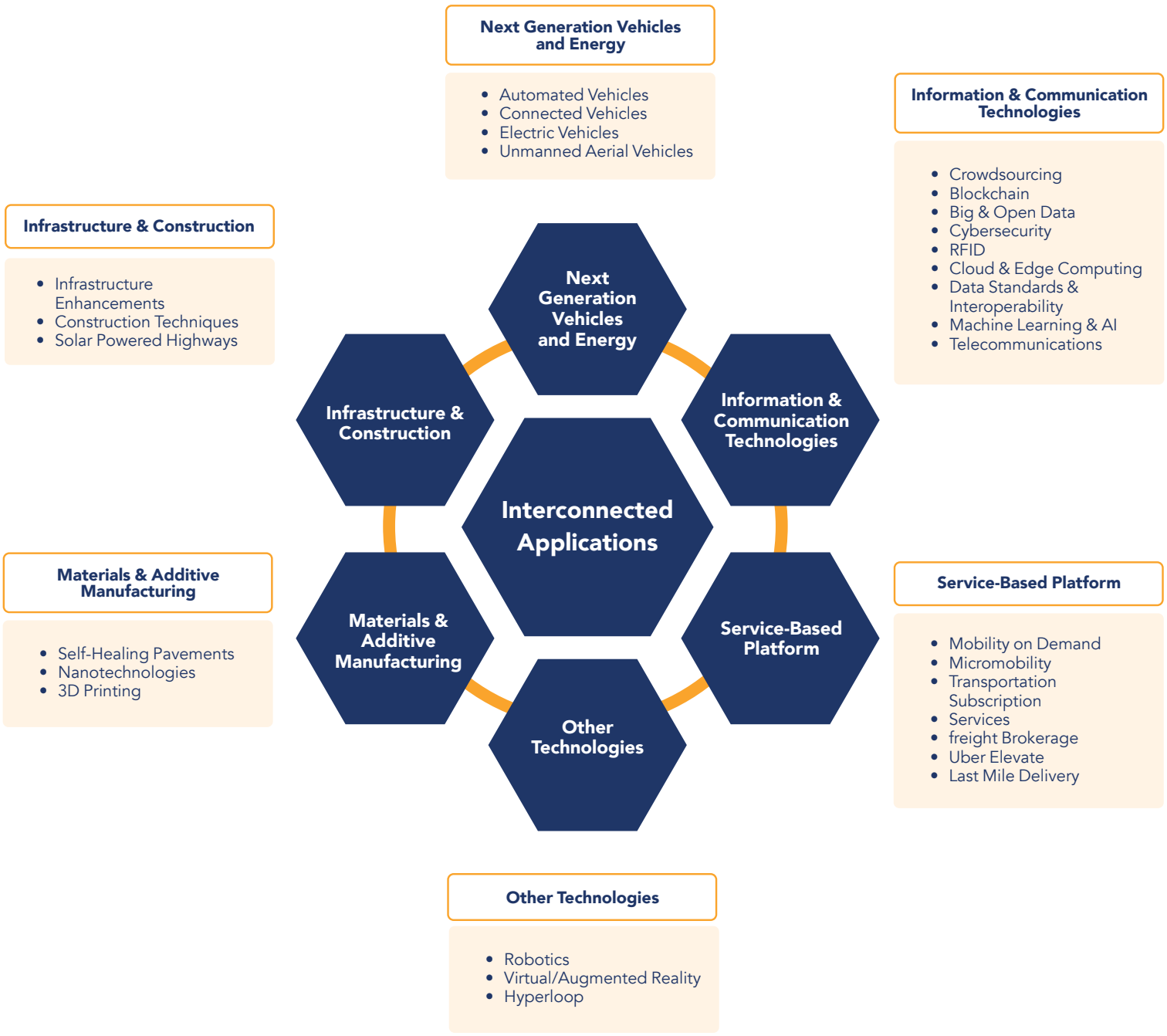
For technologies in the Portfolio, the Task Force maps transportation applications and use cases, assesses alignment with transportation goals, identifies barriers to implementation, and determines maturity. The Portfolio informs the composition of the Task Force, meeting topics, and white papers. The Task Force considers which technologies may be competing, complementary, or evolving at different paces. The Task Force draws upon information from subject matter experts (individuals with experience and deep technical understanding of technology processes, implementation, and research and development), and industry reports to develop the list of technologies for the Portfolio. The Emerging Technology Portfolio serves as the basis for the technology discovery process, technology evaluation and prioritization, and major components of the Technology Utilization Plan.

## Plan

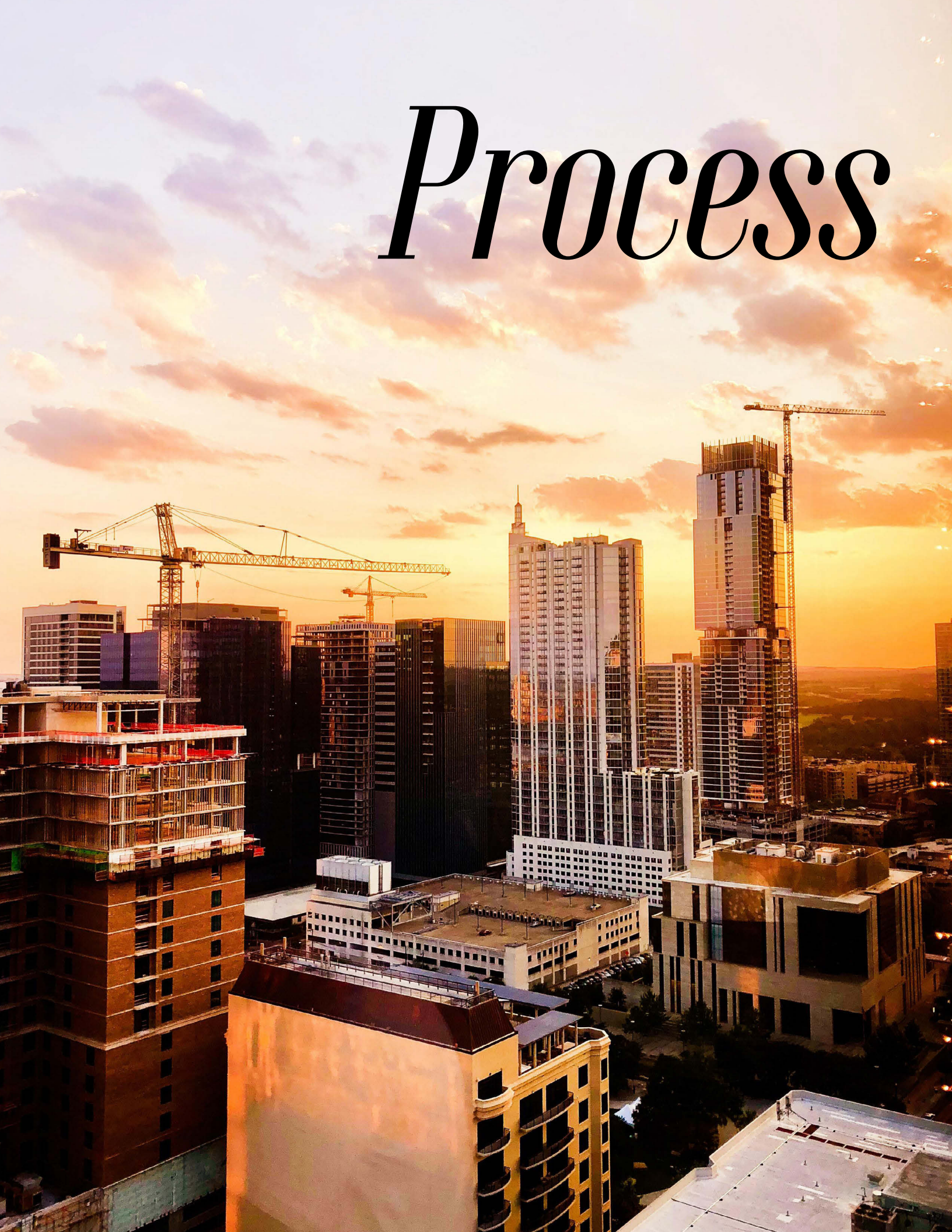
The Task Force develops several documents that are intended to assist in TxDOT's planning activities. The first is the annual issuance of technology white papers on critical topics. Three to five white papers are developed each year in order to provide timely information on innovative technologies, policies, or programs. The Task Force selects white paper topics based on input from the Task Force activities with TxDOT staff and industry experts focusing on areas in which there is critical interest and a number of outstanding questions. The white papers are composed in a manner to serve as a mechanism to bring the most-up-to-date information to TxDOT and other stakeholders and inform strategies in the Technology Utilization Plan. Elements of the white papers contain, but are not limited to, information on technical details of technologies and their real-world applications, potential business models or markets, political and societal trends bearing an impact on technologies, identification of opportunities for utilization and adoption in Texas, and case studies on ongoing trials or pilots, when possible. Next the Task Force develops and maintains a Communications & Stakeholder Engagement Plan that characterizes stakeholder groups, such as elected officials, other state agencies, TxDOT divisions, industry sectors, the public, etc., and defines, at a minimum, appropriate messages, informational materials, and communication channels. The plan outlines proposed methods of outreach and involvement of various stakeholders throughout the strategic planning process.

The final planning document is this Technology Utilization Plan, which is intended to serve as a strategic guide on the anticipation and inclusion of advanced technologies for the Texas transportation system and within TxDOT. The Task Force works to continually familiarize itself with ongoing efforts within TxDOT to create an Emerging Technology in Transportation Plan. Where possible, the Task Force has developed the Technology Utilization Plan in a manner to supports the development of the Emerging Technology in Transportation Plan. Further, the Task Force will continue to work with TxDOT staff on an as-needed basis to support the development of the Emerging Technology in Transportation Plan. The Task Force formed the Technology Utilization Plan through a multi-step process that draws from all of its activities and includes, but is not limited to, elements such as technology market forecasting, evaluation of benefits and barriers, technology maturation requirements and planning, lessons learned from early trials, and technology adoption strategies. The Technology Utilization Plan aims to define a technical end-state enabled by technology adoption over time. The Plan identifies opportunities for TxDOT to use advanced technology to reasonably meet existing and anticipated goals in the near and long term.

## *Figure 1: Emerging Technology Portfolio*



# Process



# PROCESS

The Task Force meets regularly with TxDOT staff to determine internal technology questions and priorities. The Task Force hosts meetings quarterly at TxDOT headquarters to engage industry subject matter experts through deep-dive presentations, panel discussions, and roundtables. These meetings also provide an opportunity for Task Force members and TxDOT staff to discuss technologies; address open questions; formulate recommendations for additional research, implementation; or generate new policies, procedures, or programs to advance technology in Texas.

Figure 2 shows how Process drives the Task Force's People, Portfolio, and Plan activities.

The Technology Utilization Plan has been developed over three phases: 1) evaluation of benefits and barriers to technology adoption, 2) synthesis of best practices and lessons learned, 3) delivery of technology utilization plan with recommendations. Figure 3 shows the successive phases with timelines for each. More detail on these phases are provided below.

## Phase I: Priority Technologies & Assessment

Phase I focused on prioritizing technologies in the Emerging Technology Portfolio. Input was provided by Task Force members, TxDOT staff, and industry experts. Six priority technologies were selected and include:

1. *Autonomous vehicles*
2. *Connected vehicles*
3. *Electric vehicles*
4. *Mobility-as-a-service*
5. *Unmanned aerial systems*
6. *Big & open data*

It was also recognized that augmented reality, blockchain, Hyperloop, and 5G telecommunications were important technologies to continue to monitor more closely.

## Phase II: Best Practices & Lessons Learned

Phase II focused on collecting best practices and lessons learned for technology and innova-

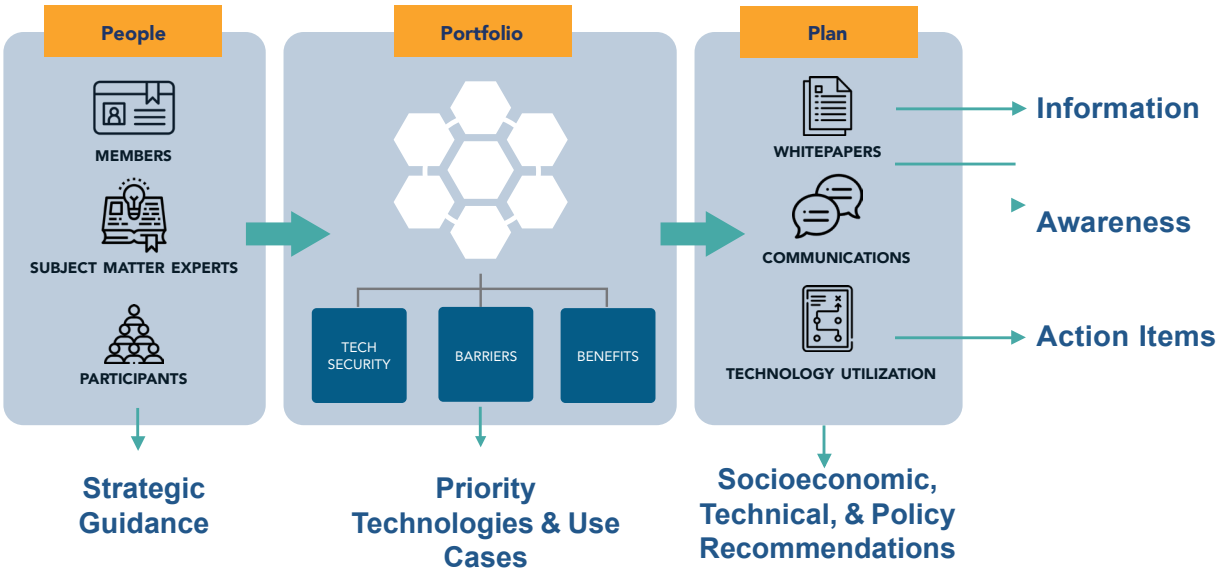



***Figure 2: Task Force People, Portfolio, Plan, and Process***

tion deployment and helps to identify methods, programs, and technical implementations that can be leveraged by fast following agencies for replication. Best practices and lessons learned are sometimes gathered by official external agencies that conduct reviews and evaluations, or are sometimes realized from reflection and interviews with practitioners participating in pilot programs.

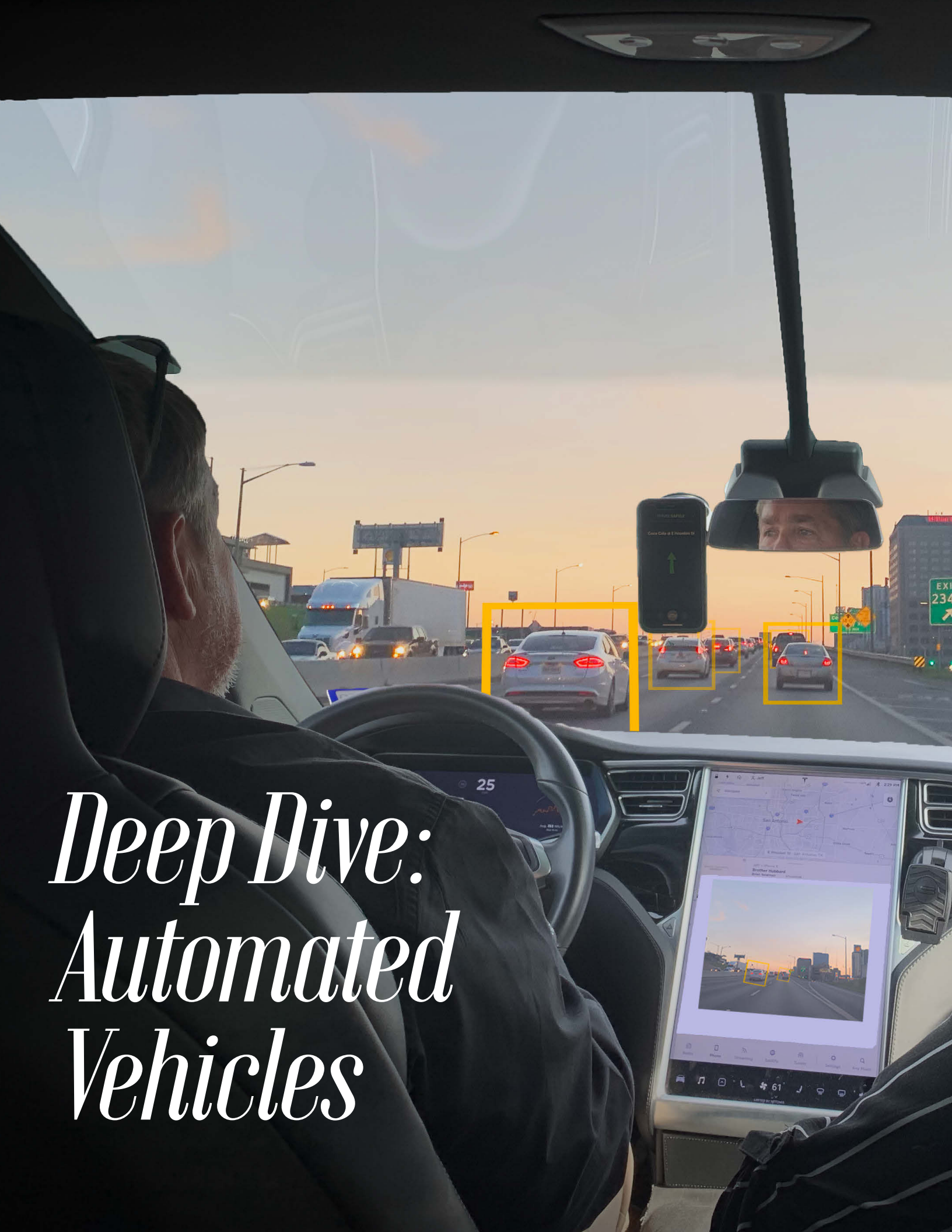
- Best practices differ from lessons learned in that they often loosely meet the following criteria:
- Measurable – meaning that goals and objectives are clear and that progress toward them can be measured.
- Successful – not only are there good results, but the pilot program progresses toward achieving its goals more than similar pilots.
- Replicable – the method or program is structured and documented clearly enough so that it can be reproduced elsewhere.

Lessons learned captured both the positive and negative experience of projects and draw from reflections from individuals performing or participating in the project. Lessons learned can be used to improve future projects and future stages of current projects. Lessons learned from key interviews and case studies are provided for each of the top six priority technologies in later sections of this plan.

## Phase III: Readiness Evaluation & Recommendations

Phase III focused on developing recommendations and actions for technology advancement. Examples may include allocating resources such as funding for technology deployment, craft regulations and policies, provide user training, conduct research, or keep the status quo. Recommendations for each of the top six priority technologies are provided in later sections of this plan.


***Figure 3: Technology Utilization Plan Phases and Timeline***



# Deep Dive: Automated Vehicles

# AUTOMATED VEHICLES

Automated vehicles have continued to rapidly progress in development and deployment during the previous three years. The number of passenger vehicles containing level 2 technology has notably increased on the nation's roads along with the advancement of automated freight vehicles and initiatives in automated transit. To allow for the continued development of more advanced vehicle automation, vehicle safety standards and policies at both the federal and state level have been reviewed and updated.

**Maturity Scale**

**Concept** — **Operational**

## KEY TAKEAWAYS

**Short-Term.** Promote and develop law enforcement education and interaction training. Establish uniform crash and incident reporting across agencies. As part of best practices, collaborate with current freight deployments for standardized data collection opportunities and safe operations.
**Long-Term.** Creation of federal and state regulations that remove barriers to deployments while promoting safety. Establishment of a consumer education program to share information on the capability of AVs at various levels and promote the safe operation of these new technologies.

**Active Deployments**

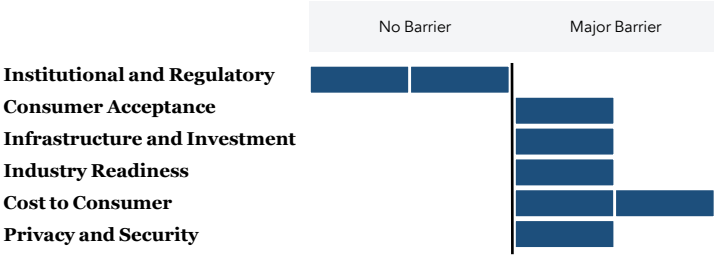
- GM Cruise- San Francisco driverless taxi
- TuSimple Arizona operations
- May Mobility and Via on-demand transit

| Readiness Index | Policy | Deployment | Research | Public Education |
|---|---|---|---|---|
| 7 | ⚙ | ⚙ | ⚙ | ! |

*Legend:* ! =High Priority ⚙ =Needs Work — = Not Urgent

## GOAL ALIGNMENT


## BARRIER ASSESSMENT




## USE CASES

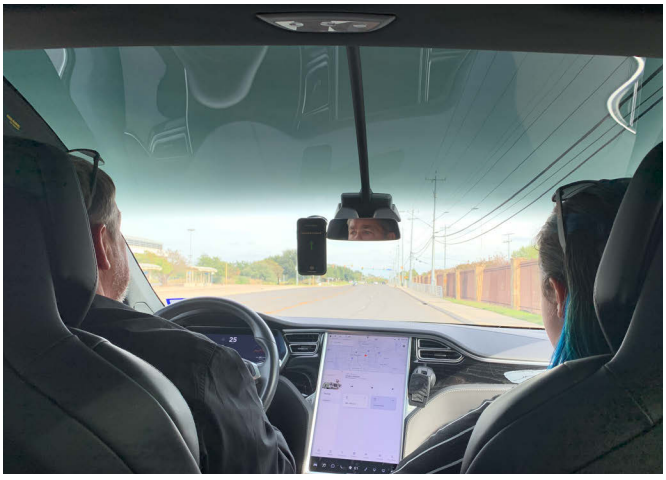
- **Passenger Vehicles**: Driverless taxi deployments highlight the potential for increased safety as they remove human distraction. Federal oversight has increased to ensure crash data is being adequately provided and analyzed.
- **Freight:** Automated freight operations and remote platooned operations have the ability to lower shipping costs which is beneficial to both consumers and freight corporations.
- **Transit**: On-demand scalable services can be operated in areas that have previously not had service, increasing transit accessibility and equity. Additionally, the full size automated buses being developed through the Automated Bus Consortium have the potential to increase transit reliability and sustainability.

# Analysis: Automated Vehicles

Automated vehicles (AVs) have systems designed to assist the driver with certain tasks (e.g., lane-keeping assistance, automatic braking, parking assistance) with more advanced prototypes designed to fully complete all the driving tasks along a route without the need for human takeover. By removing the driver from the operation of passenger vehicles, it is believed that road safety will increase, both for passengers in the vehicle and vulnerable road users. With the potential for increased safety and the ability to supplement the changing workforce, automated vehicles have seen an increase in development and number of deployments in the last few years.

## Passenger Vehicles

As development of AVs has advanced, the number of self-driving vehicles on the road has increased. Companies developing AVs—Argo, Waymo, and GM Cruise, for example—have begun self-driving vehicle ride operations in suburban areas of Austin, Texas, Phoenix, Arizona, and San Francisco, California. Argo's operations in Austin include the rollout of passenger service. Waymo's operations, launched in Phoenix in 2018, has expanded to provide employees free rides in California as well. While Waymo has limited operations in California to employees, GM Cruise has recently received permit approval by the California Public Utilities Board (CPUB) to provide rides to the public. To ensure the safety of AV operations, the CPUB limited the vehicles to operations at less than 30 mph, avoidance of downtown areas, no operations during the hours of 10 pm to 6 am or during heavy fog, precipitation, or smoke events. (GM's Cruise wins first California permit to carry paying riders in driverless cars | Reuters).



To remove current barriers to AV design, developers have advocated in recent years for US vehicle standards to be updated to include provisions for fully automated vehicles, including the removal of requirements that assume vehicles will have manual controls. After safety reviews, US regulators revised crash standards to remove fully autonomous vehicles from being equipped with manual controls. First proposed in early 2020, the revisions emphasize that automated vehicles must still provide the same level of occupant protection as traditional human-driven vehicles. (US eliminates human controls requirement for fully automated vehicles | Reuters).

Other USDOT activities over the last few years have involved the monitoring of AV crash data in response to a number of high-profile crashes involving AVs. Issued in mid-2021, the NHTSA Standing Order 2021-01 (Incident Reporting for Automated Driving Systems [ADS] and Level 2 Advanced Driver Assistance Systems [ADAS]) requires manufacturers and operators of vehicles equipped with SAE level 2 ADAS or SAE level 3-5 ADS to report certain crashes to NHTSA when systems are engaged. The aim

of Standing Order 2021-01 is to ensure AV technology is being deployed safely and to educate and build confidence of consumers in these advanced technologies. (NHTSA Releases Initial Data on Safety Performance of Advanced Vehicle Technologies)

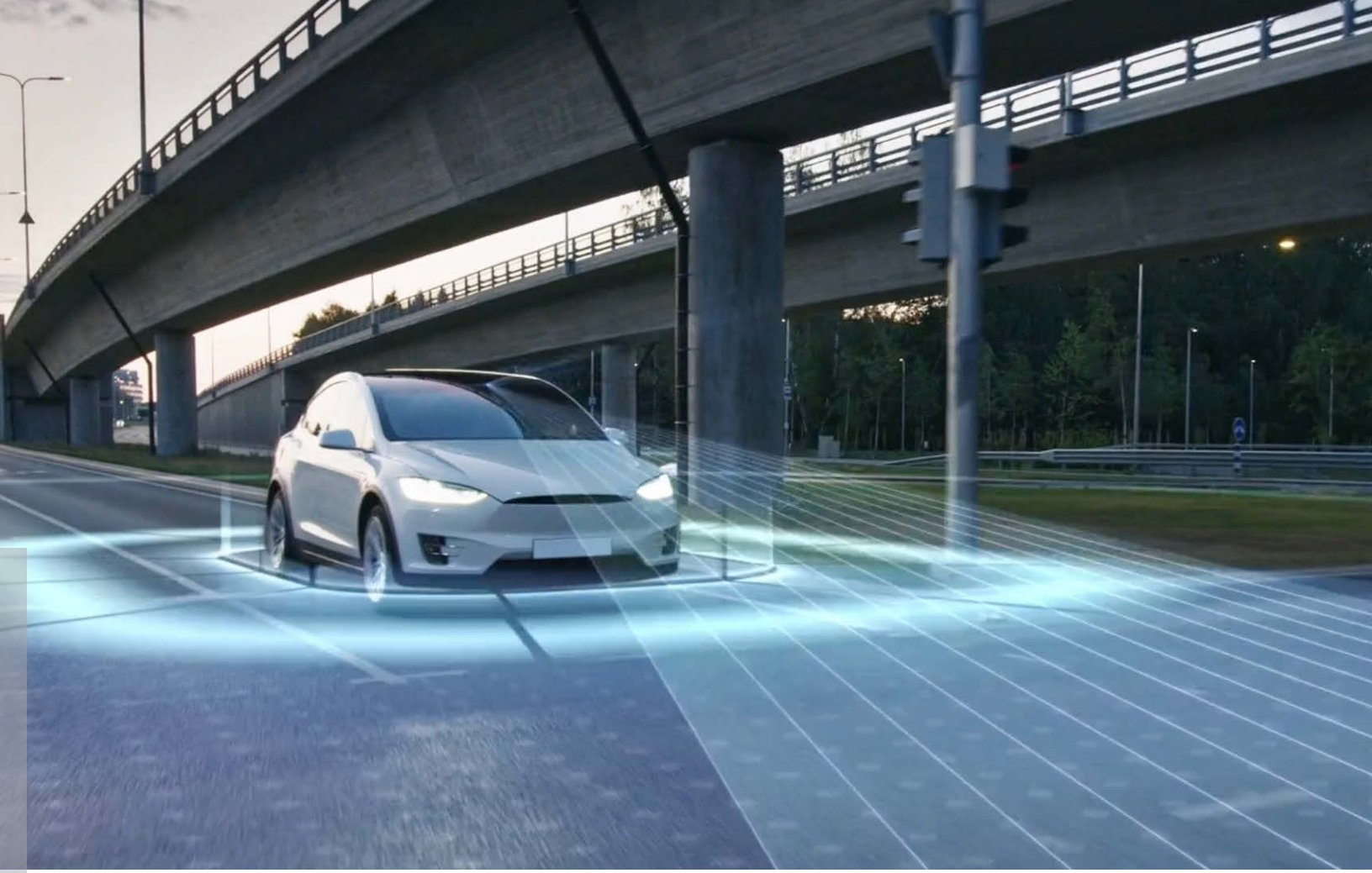
## Freight Industry

The freight sector has made strides toward automation in the last two years. Several deployments have been made within Texas, including by Waymo, TuSimple, Aurora, Embark, and Kodiak Robotics. Two have completed fully automated trips, with TuSimple operating between Tucson and Phoenix, Arizona, and Kodiak operating between Houston and Dallas, Texas. (TuSimple completes its first driverless autonomous truck run on public roads | TechCrunch) Recently, Waymo and Uber have announced a partnership to leverage the two companies' expertise to launch a fleet of autonomous trucks in an effort to reduce shipping costs. (Waymo And Uber Partner On Autonomous Truck Rollout | Carscoops) With the number of automated freight trucks expected to reach 1 million in the next ten years, the Federal Motor Carriers Safety Administration is preparing to release a rulemaking for fully automated trucks by the end of the year. (Automated trucks and buses projected to reach 1.2 million by 2032 FMCSA Technology Chief Says Automated Truck Proposal Targeted for Late 2022 | Transport Topics)


## Transit

Over the last three years, companies in the transit sector have executed unique AV deployments. Demonstrating scalability and integration into existing transportation services, May Mobility and Via launched three AV deployments in less than a year. These services in Arlington, Texas, Grand Rapids, and Ann Arbor, Michigan, are on-demand, dynamically routed and use-shared AV models. Additionally, these on-demand services can be scaled to a city's needs, with each city seeing month-over-month increases in ridership. (May Mobility and Via launch three unique autonomous vehicle services in only 8 months | VIA)

Along with on-demand services, transit operators have begun the process to introduce full-size automated buses to their fleet. Managed by AECOM, the Automated Bus Consortium (ABC) brings together transit organizations from across the country to assess and develop automated transit buses. Recently, the ABC issued a request for proposal to procure up to 70 SAE level 4 full-size automated buses. The buses will be deployed for revenue service on pilot routes selected by participating agencies. The results from these pilots will be used to inform future operations and development of automated vehicles. (Automated Bus Consortium Issues Request for Proposals | Business Wire)



## Recommendations

Based on updates during the past couple of years, opportunities for advancing automated vehicle technology in the short- and long-term include the following:

### *Short-Term*

- Develop law enforcement education programs and AV interaction plans.
- Establish uniform incident reporting standards across agencies.
- Promote collaboration between current and future development and deployment stakeholders.

### *Long-Term*

- Establish federal and state regulations that promote safety and remove barriers to deployments.
- Develop consumer education programs to provide knowledge on AV capabilities and limitations.
- Identify planning considerations to reconfigure end-to-end AV trucking transitionary stations.

# Deep Dive: Connected Vehicles

# CONNECTED VEHICLES

Connected vehicles (CVs) enable the transfer of information between vehicles, connected roadside infrastructure, and other road users. With real-time information about road conditions and driver behavior, CV technology can improve both operations and planning. Recent FCC rulings have created uncertainty around deployment strategy, but Texas is well-positioned to advance and scale CV operations.

**Maturity Scale**

**Concept** — **Operational**

## KEY TAKEAWAYS

**Short-Term.** Monitor developments in FCC regulations and track deployment strategies from peer agencies. Invest in pilots that demonstrate 5G capabilities. Leverage data exchange platforms to support CV applications.
**Long-Term.** Use federal funding opportunities to advance the CV environment. Follow standards for CV applications and data exchanges.
**Active Deployments**

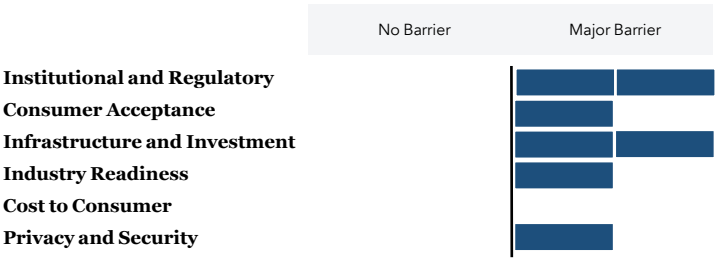
- OEMs Invest in C-V2X Technology
- ITS4US Demonstrates CV Applications for Vulnerable Road Users
- Emerging Applications Focus on Safety

| Readiness Index | Policy | Deployment | Research | Public Education |
|---|---|---|---|---|
| 5 C-V2X | ⚙ | ! | ! | ⚙ |

*Legend:* ! =High Priority ⚙ =Needs Work — = Not Urgent

## GOAL ALIGNMENT


## BARRIER ASSESSMENT




## USE CASES

- **Roadway Conditions and Hazards**: Roadway users can be given notice of slowdowns, debris, and infrastructure conditions.
- **Congestion Management:** CVs can provide real-time travel information that helps network operators manage congestion and improved roadway efficiency.
- **Speed Limit Control:** Fleet managers or infrastructure owner/operators can set geographic speed limit restrictions that improve safety.
- **Pedestrian and Cyclist Safety:** CVs can detect and communicate with vulnerable road users, like pedestrians and cyclists, to create safer multimodal interactions.
- **Driver Behavior and Patterns:** Data on origin/destination, travel behavior, and roadway users can support long-range planning efforts.

# Analysis: Connected Vehicles

Connected vehicles communicate information between other vehicles (V2V), infrastructure (V2I), and other connected devices like cell phones (V2X). CV technology can provide roadway condition and safety information to drivers, such as warnings for work zones, unexpected slowdowns, and nearby pedestrians. Infrastructure owners/operators (IOOs) and agencies can also use anonymized CV information, such as origin and destination data, real-time location and speed, and braking behavior, to improve planning and operations. OEMs are investing in CV technologies and many have pledged to connect all of their models within the next few years. Many states are developing or expanding their CV programs and new funding opportunities are becoming available through the Infrastructure Investment and Jobs Act (IIJA). While Federal Communications Commission (FCC) rulings on the 5.9 GHz (5G) band have created delays and uncertainty for the industry, industry leaders are pushing ahead in adopting and deploying CV technology.

## FCC Rules on Safety Band

In 1999, the FCC reserved 75 MHz of the 5.9 GHz band (safety band) for dedicated short-range communications (DSRC) to support the emerging intelligent transportation systems (ITS) field. Adoption and deployment of DSRC technology was slow, so in November 2020, the FCC ruled to re-allocate 60 percent of the 5.9 GHz band to non-transportation uses. Additionally, the FCC will require all existing DSRC deployments to transition to C-V2X by July 2022, which would require agencies to replace their roadside units (RSUs) if they are not dual-mode (capable of both DSRC and C-V2X transmission).

The FCC rulings were met with pushback from the USDOT, ITS America, AASHTO, and other industry groups who are concerned that the decision compromises the scope and safety of CV technology. A working group led by ITS America stressed that 30 MHz is not sufficient spectrum to support existing and anticipated safety-critical V2X technologies such as vehicle-to-pedestrian (V2P). Additionally, because the lower 45 MHz was re-allocated to non-licensed WiFi uses, the USDOT and other stakeholders have expressed concerns that the safety band could be subject to harmful interference. ITS America and AASHTO jointly sued the FCC in June 2021 in an effort to reverse the spectrum reduction. The suit did not appeal the DSRC to C-V2X transition. Oral arguments were heard before the District of Columbia Circuit Court in January 2022 and a ruling is expected in summer 2022.

The Florida, Georgia, Utah, Virginia, and Ohio departments of transportation, as well as equipment makers such as Kapsch, Danlaw, and Ford, have requested FCC waivers that will allow them to continue DSRC operations. Each of these states were early CV adopters and have large DSRC deployments.

## IIJA Offers Flexible Funding

Agencies looking to invest in CV technology can count on federal funding through the IIJA, which includes provisions focused on CV technology and cybersecurity, including special eligibility for retrofitting DSRC and CV technology that serves vulnerable road users, like pedestrians.

The Promoting Resilient Operations for Transformative, Efficient, and Cost-saving Transportation (PROTECT) Program is a new grant for projects that install technology components, telecom equipment, and/or ITS infrastructure. The Strengthening Mobility and Revolutionizing Transportation (SMART) grant funds projects that include CV components, intelligent sensor-based infrastructure deployments, and/or other smart city technology. The Advanced Transportation Technologies and Innovative Mobility Deployment (ATTIMD) grant program modifies the existing ATCMD program by expanding its objectives to make V2P technology and retrofitting DSRC assets eligible. Finally, the new Carbon Reduction Program

(CRP) funds the installation of Vehicle to Infrastructure (V2I) equipment and DSRC retrofitting.

Cybersecurity for transportation infrastructure and CV equipment is a growing focus, and the IIJA provides $1 billion of funding eligible for transportation-related purposes. Additionally, funds from major FHWA programs can now be used to address cybersecurity threats, and the FHWA is developing a tool to help agencies in identifying and combating cyber incidents.

# Case Studies

## OEMs Invest in C-V2X Technology

Ford is the first automaker to mass produce C-V2X technology, which it rolled out in China in 2021 and in all new vehicle models starting in 2022. Audi is piloting C-V2X technology in partnership with Virginia DOT and is partnering with Verizon to bring 5G connectivity to all of its new vehicles in 2024. GM and AT&T are teaming up to bring 5G to Chevrolet, Cadillac, and GMC cars by 2024. OEMs including GM, Ford, Nissan, and Hyundai have concluded a year-long, on-road test of C-V2X as part of a Crash Avoidance Metrics Partners LLP (CAMP) effort to understand spectrum needs.

## ITS4US Demonstrates CV Applications for Vulnerable Road Users

Four pilot projects in USDOT's ITS4US program were funded for Phases 2 and 3 in June 2022. The program is focused on providing efficient, affordable, and accessible transportation solutions for underserved communities, including persons with disabilities, elderly, low-income communities, and rural residents. The pilots demonstrate how CV data can be used to support complete trip planning that considers accessibility-related needs. For example, a University of Washington (UW) project called the Transportation Data Equity Initiative uses CV data to create an application that helps blind and low-vision persons navigate and explore the environment. UW has also created a simulation tool that allows travelers to explore the layout of transit stations prior to using those facilities.

## Emerging Applications Focus on Safety

Safety use cases remain among the most important CV applications, even as new capabilities emerge. Work zone warnings and road hazard alerts are continually refined and deployed in large pilots, and newer safety applications are gaining interest. The NYC Connected Vehicle Project was the first to pilot the pedestrian-in-crosswalk V2P application. In Atlanta, C-V2X-based signal preemption, typically used for transit or emergency vehicles, is being expanded to improve intersection safety, particularly for school buses. In Germany, Ford is trialing a geofencing technology that could automatically reduce vehicle speeds. The CV technology would also allow owners to set their own geofencing zones at lower speeds to accommodate private facilities, warehouses, and more.

## Recommendations

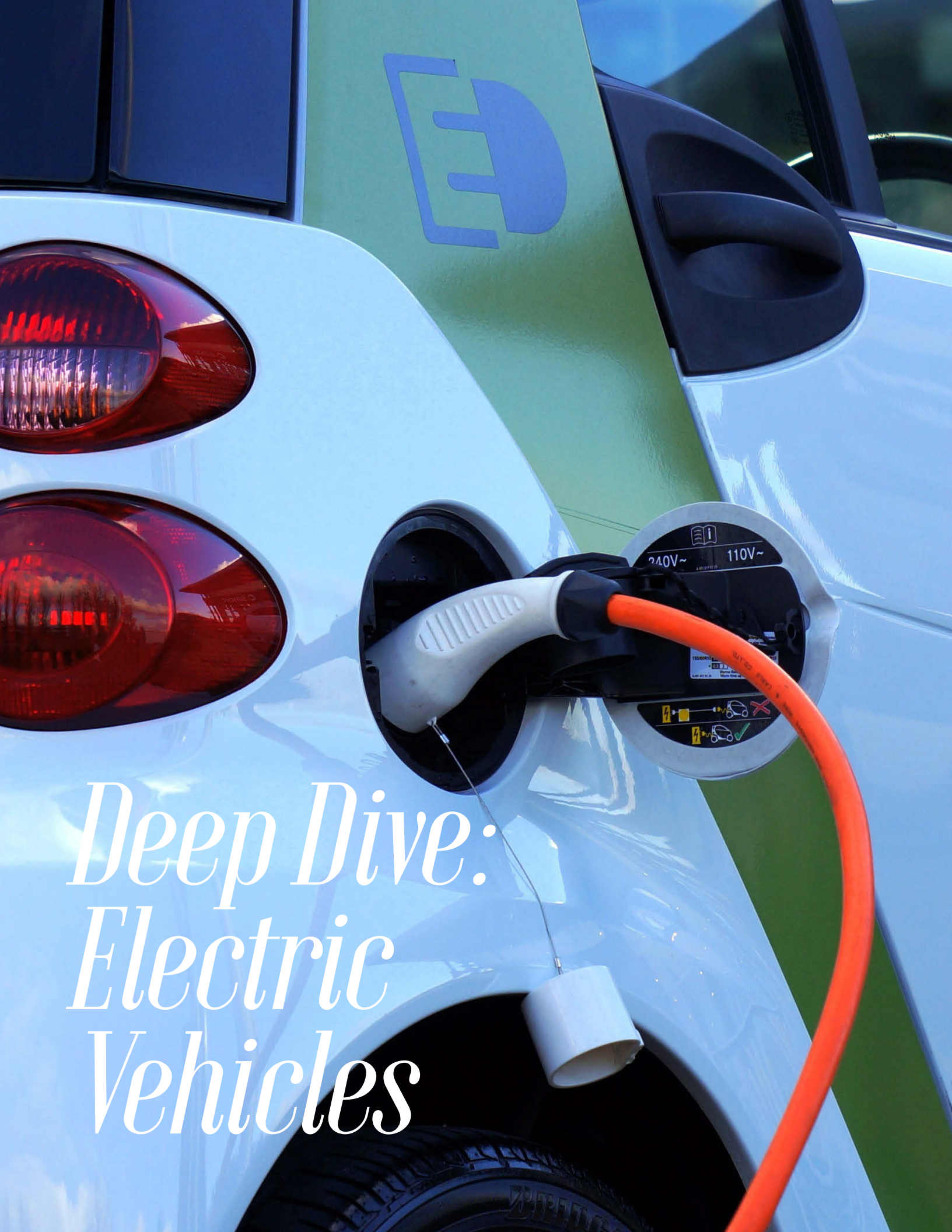
Based on updates over the past couple of years, opportunities for advancing the technology in the short- and long-term include the following:

***Short-Term***

- Monitor developments on FCC regulations, V2X specifications, and application standards.
- Look to other pilots for lessons learned.
- Follow the lead of automakers: for CV technology to be effective, it must exist densely, so high adoption is essential.

***Long-Term***

- Take advantage of federal funding opportunities.
- Partner with other industry stakeholders where possible—passenger OEMs, CV technology providers such as Qualcomm, The Ray.
- Integrate cybersecurity practices into ITS equipment.

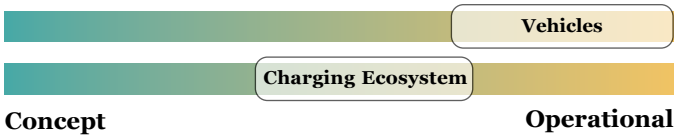



# Deep Dive: Electric Vehicles

# ELECTRIC VEHICLES & ALTERNATIVE FUELS

Progress made in both technical and logistical aspects of electric vehicles in recent years have put them on a trajectory for rapid adoption. Consumers and companies have begun to see the cost savings of switching to electric options, and some car manufacturers will switch completely to electric by the end of the decade. This is important for Texas in that it will create emission and noise-reduction benefits that will translate to better health outcomes, efficiency gains for city transit networks, and it will help increase resiliency of Texas's transportation network.

**Maturity Scale**




## KEY TAKEAWAYS

**Short-Term.** Increase consumer education and build out supporting infrastructure through federal funding opportunities to increase the adoption of electric vehicles.
**Long-Term.** Find alternative funding mechanisms to ensure that electric vehicle users are contributing toward the construction and maintenance of Texas's transportation system. Monitor developments in battery technology that will lead to cost reductions in the price of electric vehicles.

**Active Deployments**

- Houston Metro's Investment in Electrified Bus Network
- Clean School Bus Program
- Amazon's Electrification of Last Mile Fleet

| Readiness Index | Policy | Deployment | Research | Public Education |
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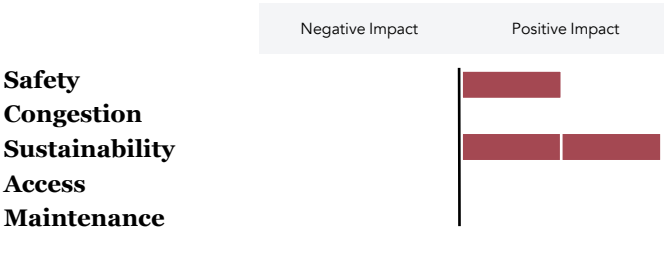
| 8 Vehicles | ! | ! | ⚙ | ⚙ |
| 4 Charging Ecosystem | | | | |

*Legend:* ! =High Priority ⚙ =Needs Work — = Not Urgent

## GOAL ALIGNMENT

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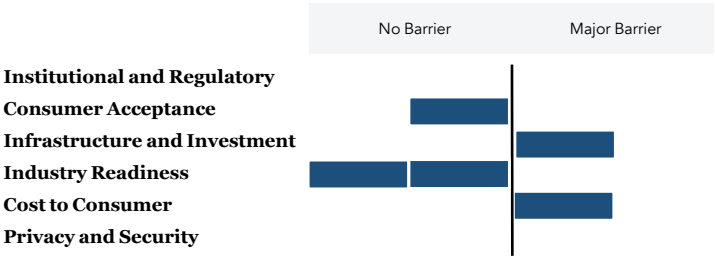


## USE CASES

- **Passenger Travel**: Major manufacturers such as Ford, Toyota, Honda, Volvo, and Volkswagen have announced fully electric and plug-in hybrid vehicle models that will increase EV adoption in the US and Texas. For the first time, more than 50 percent of potential car buyers are considering EVs and the sales of traditional combustion engine vehicles continues to decline since its peak in 2017.
- **Transit**: While electric buses have a significant upfront cost, they recoup major fuel cost savings and emissions reductions compared to their diesel counterparts. Several Texas transit agencies are in the process of transitioning their fleets to electric.
- **Freight**: Electric vehicles are seeing a surge in adoption in the middle- and last-mile applications for companies like Amazon, FedEx, and USPS that are electrifying their fleets. The cost savings of EVs are significant over time but require steep upfront investment.

# Analysis: Electric Vehicles and Alternative Fuels

Electric and alternative-fuel vehicles replace a traditional combustion engines to provide a more sustainable, higher performance, and cost saving alternative. Their increased adoption has been encouraged by the instability of oil prices and the increased cost of ownership for gasoline and diesel vehicles. Most vehicle manufacturers are now offering or plan to offer either hybrid or fully electric models in the near future and many have already pledged to phase out their traditional offerings in the next two decades. This is a result of an increased consumer desire for alternative fuel options due to their lower maintenance costs and environmental benefits. While the technology still has areas that are under ongoing development, it has now matured to the point where EVs and some alternative fuel deployments are widespread and common. To best maximize the benefits of this transition, a strong policy response and infrastructure plan will be necessary in the near future to aid roadway and infrastructure maintenance.

## Charging Infrastructure

Sufficient charging stations are of immense importance to realize the viability of both consumer and commercial EV applications. While most EV owners utilize home charging options for the vast majority of their charging needs, having access to an interconnected network of fast charging stations along key corridors is essential to combat barriers to adoption like range anxiety, charging station congestion, and equity of access. Some cities like Austin have adopted programs to provide level 2 charging for a low monthly fee in order to ensure those who can't charge at home are well served. Using National Electric Vehicle Infrastructure (NEVI) Formula Program guidance and in accordance with FHWA guidelines, Texas is seeking to develop a skeleton of chargers to ensure no more than a fifty-mile distance between stations. This network will take time to rollout and may take years for EVs to reach market saturation.

## Policy

The passage of the IIJA promises to kickstart massive investments in infrastructure to support electric vehicles. Texas is expected to receive more than $3 billion dollars over the next five years to fund a wide range of essential infrastructure, including EV chargers. The Texas governor has emphasized rural connectivity as a key consideration for these efforts in order to ensure the feasibility of EVs for Texans who do not live on major corridors. Due to the higher energy demands resulting from the increase in EV chargers, collaboration between both private and public actors in the energy sector will be vital to ensure reliability and efficiency of rollouts.

## Battery Technology

The lithium-ion battery, currently found in a majority of electric vehicles, has sufficient capacity to deliver substantial range and performance. Scarcity of crucial components, however, has led to industry members like GM and Samsung Technologies investing millions of dollars into the development of next generation "solid state" batteries made of more available graphene and other forms of carbon. Solid state batteries promise higher energy density and are much more stable and less prone to degradation and fire risk. Despite high levels of investment, this technology is not expected to appear in commercial vehicle applications until closer to the end of the decade due to the need to overcome challenges in the manufacturing process.

## Next Steps

Collaboration and communicating best practices between cities and agencies will be necessary to combat barriers to adoption and ensure the viability of the technology. Additionally, it will be beneficial to examine the effectiveness of the technology from a holistic perspective that incorporates economic and social externalities to best leverage the technology to benefit Texans.

## Recommendations

Based on updates over the past couple of years, opportunities for advancing the technology in the short- and long-term include the following:

**Short-Term**

- Leverage IIJA funding to fill in gaps in charging networks especially in rural areas.
- Emphasize best-practice sharing to inform future deployment of infrastructure in the state.
- Highlight industry partnerships and collaborations to consider all potential economic and social implications.

**Long-Term**

- Develop alternative funding mechanisms to address reduced revenue from state gas tax.
- Consider consumer education efforts to minimize transitional challenges.
- Coordinate with energy providers to ensure capacity considerations are met.

# Deep Dive: Unmanned Aerial Systems

# UNMANNED AERIAL SYSTEMS

Unmanned aerial systems (UAS or drones) are being developed for uses ranging from public safety to on-demand mobility. In recent years, significant progress in federal guidance and industry deployment have occurred. However, several barriers prevent full integration of UAS. TxDOT should continue to monitor federal guidance and pursue opportunities to join key programs.

**Maturity Scale**


## KEY TAKEAWAYS

**Short-Term.** Prioritize use-case deployments; development state policies to alleviate inter-jurisdictional issues; identify UAS test corridor for package delivery.
**Long-Term.** Follow federal policy developments to anticipate guidance; consider joining programs like BEYOND; seek opportunities to collaborate with companies developing air taxis.
**Active Deployments**

- Wing
- Walmart
- (Inspection)

| Readiness Index | Policy | Deployment | Research | Public Education |
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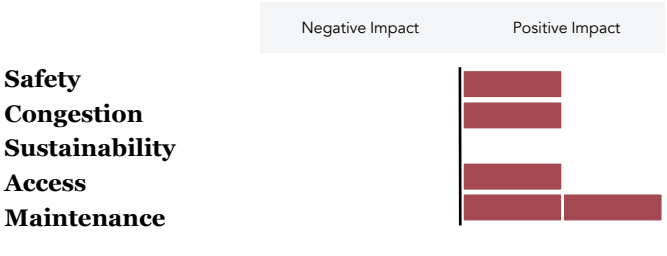
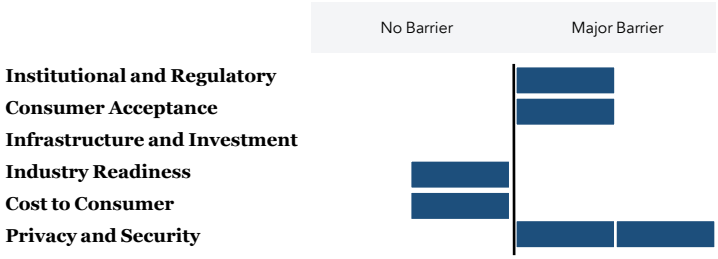
*Legend:* ! =High Priority ⚙ =Needs Work — = Not Urgent

## GOAL ALIGNMENT




## BARRIER ASSESSMENT




## USE CASES

The versatility of UAS provides a wide array of technology applications to consider in the transportation, public safety, and medical sectors:

- **Last-Mile Package Delivery.** Packages are delivered more quickly and efficiently, reducing their contribution to surface traffic.
- **Traffic Incident Reconstruction.** Drones equipped with LiDAR technology are being used for incident reconstruction and to more quickly clear travel lanes.
- **Infrastructure Inspections.** Drones aid in inspections of critical infrastructure like bridges, highways, and rail.
- **Medical Supply Delivery.** UAS are being tested to expedite the delivery of critical medical supplies for operations such as blood transfusions.
- **Urban Air Mobility.** Industry is continuing to pursue development of vehicles and business models for urban air mobility to carry passengers between key destinations.

# Analysis: UAS

UAS, also referred to as drones, are a versatile technology with a wide array of technology applications for public agencies to consider. Drones are being developed for uses ranging from public safety to on-demand mobility. UAS differ from ground vehicles in that the regulatory landscape is nebulous. The Federal Aviation Administration (FAA) announced Part 107 revisions in 2021, updating a set of rules and certification required for commercial drone operation in the US. The most notable changes to Part 107 include remote ID requirements, pilot registration maintenance, and simplification to flights at night and over people. Additionally, Part 135 certification has forged a pathway for package delivery and beyond-visual-line-of-sight (BVLOS) operations. While personal drone use is common, public and private agencies are still navigating what policies and uses are most relevant and effective for UAS deployment.

## Infrastructure

Public agencies are currently using drones for a variety of applications related to infrastructure. As more uses are being identified and more agencies integrate drones into their operations, a diverse range of specialized drones saturate the market. Attachments such as anti-collision caging and specialty sensors are increasing the number of potential infrastructure uses.

Primarily, drones are being utilized for inspections of bridges, highways, and rail. Equipped with LiDAR scanners, drones can map riverbeds, underpasses, and road surfaces quickly and efficiently. Because drones can access spaces that are harder to reach, inspections are safer for maintenance workers. This also reduces the amount of time an inspection takes because drones eliminate the need for labor and equipment for dangerous activities like climbing or diving.

Drones are also utilized in infrastructure construction. Specifically, drones improve site mapping and equipment tracking efforts by providing aerial views and real-time data recording. Topographical imaging allows large land areas to be surveyed quickly, reducing time and labor costs at the front end of the project. Drones also allow agencies to track their assets at a particular site, making it easier to visualize inventory and optimize equipment logistics.

## Traffic Operations and Emergency Response

In recent years, a growing number of state and federal agencies have invested in research and test cases for UAS traffic and roadway applications. Some of the most common uses include traffic characterization (speed, vehicle counts), hazard identification (debris, accidents, unattended vehicles), and hazard assessment (road conditions, flooding, sinkholes). UAS are being deployed by DOTs as well as public safety agencies to monitor traffic in various ways, including drones used in lieu of helicopters to view traffic in areas where cameras are unavailable, to monitor vehicle counts and speeds to help facilitate traffic at special events, and used to assess highly trafficked infrastructure like roundabouts and exit ramps.

Drones are becoming increasingly utilized in public safety and emergency response operations. There are a variety of applications relevant to roadway safety and traffic management, including hazard identification (small debris like fallen limbs and tire shreds) and assessment of major events like vehicle crashes and sinkholes. Public safety officials are utilizing drones to identify and assess hazard sites resulting in quicker clearance and smoother traffic flows.

While drones are a useful standalone traffic tool, there is increasing interest in tethered operations. North Carolina DOT is launching a first-of-its-kind pilot program in which tethered drones are mounted to incident management patrol (IMAP) trucks, which allows a drone to be launched quickly to provide immediate situational awareness once an IMAP truck arrives at the scene of an incident.

Drones provide various useful applications to emergency response. For example, fire departments are utilizing UAS to assess fires using thermal imaging to determine priority areas for optimal fire suppression and containment. Fire departments are also utilizing drones to detect persons in need of rescue and potential structural hazards to reduce safety risk in burning buildings. Beyond fire service, thermal imaging and LiDAR-scanning drones also aid in search and rescue efforts, especially when it is dark or weather conditions are poor. UAS are also being utilized to monitor extreme weather events in which drones measure rising water levels, directional flow, and roadway coverage during flood events. This allows emergency responders to plan routes safely without trial and error. Broadly, drones are useful safety tools because they provide an aerial advantage and rich, real-time data.

## Package Delivery

In recent years, there has been significant interest in using drones for package delivery. But, one major barrier to drone delivery is airspace management. The FAA launched its Integration Pilot Program (IPP) program in 2017 and the BEYOND program, its successor, in 2020. The goal of both programs is to successfully integrate drone traffic into national airspace. The FAA is working to clarify commercial guidelines in Part 135 to facilitate UAS integration through a series of programs and partnerships by 2024.

Under the FAA's IPP and BEYOND programs, several companies have achieved Part 135 carrier certification. Wing Aviation was the first to achieve certification in April 2019 and began delivering food and pharmaceuticals directly to doorsteps in Christiansburg, Virginia. In September 2019, UPS Flight Forward, Inc., was the second IPP partner to achieve Part 135 certification, which allowed the company to utilize drones to deliver medical supplies to a hospital campus in Raleigh, North Carolina. In August 2020, Amazon became the first company certified to operate drones weighing more than fifty-five pounds for commercial deliveries under the FAA's Partners for Safety Plan (PSP). In June 2022, Zipline became the fourth drone operator to achieve Part 135 certification, the first under the BEYOND program. Zipline was also the first to receive fixed-wing drone certification from the FAA.

As the BEYOND program ramps up following setbacks due to COVID-19, the FAA is actively working with partners to enable safe and successful drone delivery operations nationwide. As a result, more companies are announcing their plans to deploy commercial drone operations. Most recently, Walmart, in partnership with aviation company DroneUp, announced that drone delivery will be made available to approximately four million households nationwide by the end of 2022. While it is clear that industry and the federal government are working to implement drone delivery on a larger scale, further research is needed to understand how it will be achieved.

## Urban Air Mobility

Utilizing drones and other small aircraft for urban mobility is a long-term industry goal. Aviation companies have invested heavily to develop UAS for urban air taxis. In the past two years, the FAA has awarded special airworthiness certificates to several passenger aircraft developed by major aviation companies, such as Joby. While there has been progress, this specific UAS application is in its early stages. There are major policy barriers preventing urban air mobility deployment. Issues such as airspace management, data exchange, and passenger safety are likely to be informed by FAA policies in other UAS applications. However, because air taxis will carry human passengers, the policy development will likely take significant time.

## Policy

In tandem with Part 135, Part 107 provides guidelines for commercial drone operations. In 2021, the FAA released revisions altering several key elements to Part 107 that deeply impact industry and public agencies. First, Part 107 now requires that drones be manufactured with remote ID capabilities. This means that drones will emit a unique signal, like a name tag, that

monitoring agencies can use to identify individual aircraft. Second, Part 107 established simplified guidance on night flights and flights over people. Previously, these flights required waivers. Third, Part 107 now requires anti-collision lights for night flights. Fourth, Part 107 no longer requires pilots to take an online certification exam. Instead, pilots are required to complete an online training course every two years.

While there has been significant progress with federal policy, there are still many unknowns. Two primary policy concerns include privacy and BVLOS. The FAA is partnering with agencies at the state and federal levels to oversee several concurrent programs to study, clarify, and establish guidance to fully integrate UAS into the US mobility network. State agencies like TxDOT should continue to monitor progress at the federal level and pursue opportunities to become involved with relevant programs.

## Recommendations

Based on updates over the past couple of years, opportunities for advancing the technology in the short- and long-term include the following:

***Short-Term***

- Prioritize deployments for bridge and roadway inspections.
- Coordinate with Texas Department of Public Safety to support emergency management use cases.
- Identify UAS test corridor for package delivery.

***Long-Term***

- Follow federal policy developments to anticipate guidance.
- Apply for federal programs such as BEYOND.
- Seek opportunities to collaborate with companies developing air taxis.

# Deep Dive: Big Data & Artficial Intellgence

# BIG DATA & ARTIFICIAL INTELLIGENCE

In the last three years data has become ubiquitous. Specifically, within the field of transportation, data has the potential to positively impact the transportation network by improving the ability to more accurately predict travel patterns while developing a safer, more efficient transportation system. Big data and predictive data have seen advancements in terms of accessibility and applications when solving both small- and large-scale transportation problems. Concerns over privacy and cybersecurity, however, have continued as data breaches and leaks have become more common. Texas must ensure that protections are in place for all forms of data if it wants to fully actualize the benefits of big and predictive data throughout the state.

**Maturity Scale**

**Concept** — **Operational**

## KEY TAKEAWAYS

**Short-Term.** Track various data privacy legislative efforts, specifically the implementation of the California Consumer Privacy Act, and prioritize developing a comprehensive data privacy bill at the state level. Additionally, TxDOT should look for joint data procurement opportunities in order to encourage improved collaboration and innovation among public agencies through data sharing.
**Long-Term.** TxDOT should focus on leveraging data from connected and automated vehicles (CAVs) that will likely increase in the coming years. Additionally, Texas should prioritize cybersecurity to mitigate risks associated with the state's data resources and infrastructure.
**Active Deployments**

- University of Maryland CATT Lab's Regional Integrated Transportation Information System (RITIS)
- Utah Department of Transportation's digital twin 3D model project delivery method
- State of California's California Consumer Privacy Act (CCPA)

| Readiness Index | Policy | Deployment | Research | Public Education |
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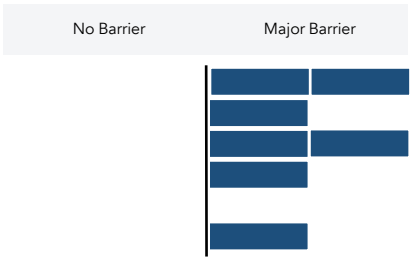
*Legend:* ! =High Priority ⚙ =Needs Work — = Not Urgent

## GOAL ALIGNMENT


## BARRIER ASSESSMENT




## USE CASES

- **Infrastructure Maintenance**: Increasingly, smart technology can obtain access to infrastructural integrity both using embedded sensors and also from external operating devices that can detect cracking or other deterioration that may not be realized upon standard routine maintenance operations.
- **Transportation Planning:** Additional travel insights by roadway users from third party sources may promote advanced insights into travel patterns and user preferences beyond what can be traditionally obtained.
- **Traffic Management:** With dynamic insights into road user travel patterns, transportation agencies have advanced opportunities to promote dynamic messaging and re-routing notifications to drivers to moderate traffic flow and limit further roadway congestion.

# Analysis: Big Data and Artificial Intelligence

The transportation system relies heavily on data to maintain the current infrastructure and plan for a more coherent and safe future road network. Applications of data-based technologies range in scale from tracking micromobility adoption, integrating new CAV-produced data sources, to improving system-wide traffic management. All of these applications are heavily influenced by both federal and state-level policies on data privacy and cyber security. Notable use cases from the past three years include four main areas of focus in tracking the influence of data in the transportation sphere: big data, predictive data, privacy, and cybersecurity. Big data and predictive data have the potential to improve response times to traffic accidents and use machine learning to predict supply chain disturbances, among many other applications. Along with the benefits of data there are drawbacks. As more data is made available to public and private agencies with the aim of improving the transportation network, that information also becomes vulnerable to attack from nefarious actors. Policies on data privacy and security should be put in place to address these concerns.

## Big Data for Traffic Operations

In the last three years big data uses for Big data uses for traffic operations have expanded during recent years. CAV technology has largely relied upon big data to navigate safely and communicate with other vehicles and infrastructure. Numerous vehicle manufacturing companies are exploring CAV technologies and, as more private and commercial CAVs are deployed on US roadways, additional data is gathered and can be used to advance technological accuracy and expand the use of the data to other applications. The University of Maryland CATT Lab has started to integrate new CAV data sources to increase accuracy of its Regional Integrated Transportation Information System (RITIS). Big data has also played a role in advancing MaaS projects. The California Department of Transportation's Integrated Travel Project (ITP) is a leading example. ITP reduces digital barriers to consumers by expanding access to transit operations' information including data about personnel, maintenance, and non-revenue services. Consumers are then able to account for network disturbances and use this information for trip planning purposes. Data platforms have helped with aggregating large datasets and providing agencies the tools to produce quick visualizations. For example, a community group in Nashville, Tennesee, was able to use the StreetLight platform to quickly illustrate how vehicle speeds had increased during the COVID-19 pandemic lockdowns. StreetLight is just one of many platforms making transportation data widely available and useful to consumers.

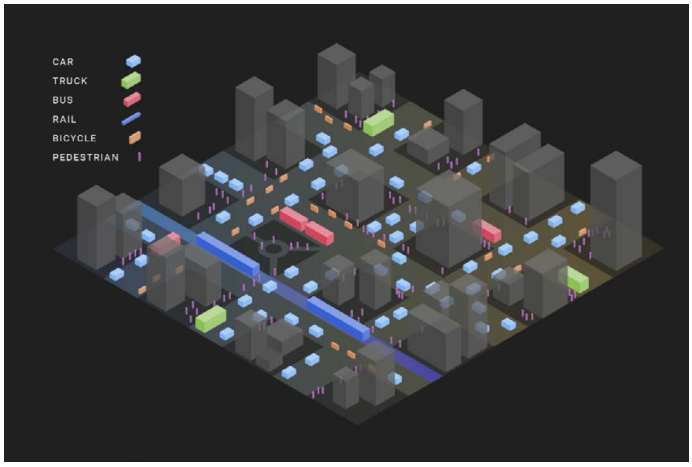



*Image: StreetLight Data, Inc*

## Predictive data analytics for planning

As with big data, advancements have been made in predictive data analytics. Digital twin technology is a recent notable advancement in this field. The benefits of digital twin technology in the transportation sector include the ability to precisely model real-world systems and utilize machine learning and projections to track performance shifts in light of infrastructure changes or events. The UK National Highways Agency has recently set out a plan to produce digital twins of the UK road network by 2050, with the goal of more easily modeling and predicting road maintenance and management issues at the national scale.


*Image: Digital Roads, NationalHighways.co.uk*

In the US, Utah DOT has already started to utilize some elements of digital twin technology to speed up the project delivery process and cut costs through 3D digital modeling. Additionally, the US federal government has shown increasing interest in utilizing predictive data analytics. USDOT recently allocated grant money as part of its Complete Trip program, which aims at utilizing innovative technology to improve transportation accessibility and mobility for persons with disabilities. Georgia DOT was awarded Complete Trip ITS4US Deployment funding, where they plan to utilize AI to help transportation users with disabilities manage route changes and safety issues when encountering unexpected objects or delays during the trip planning process.

## Data Privacy

Federal privacy legislation has been in development for years but no comprehensive bill has been passed at the national level that ensures a personal right to data privacy and protection. The European Union's General Data Protection Regulation (GDPR) from 2016 is one of the most well-known pieces of data privacy legislation that exists today. In 2018, California passed a similar law: the California Consumer Privacy Act (CCPA). CCPA, which went into effect in 2020, is still in the early stages of implementation and many are predicting that compliance and enforcement may prove challenging. The CCPA is the first of its kind in the US and should be tracked moving forward. The 87th Texas Legislature in 2021 saw some success in terms of data privacy legislation. A bill covering data protection was passed but it was by no means comprehensive, and no provisions were implemented to determine how private companies can utilize personal and private data—an increasingly serious concern for the general public in recent years.

## Cyber Security

Cybersecurity threats have increased over the past three years. The COVID-19 pandemic caused the world to dramatically alter travel patterns and conduct most of their lives online, with people accessing work, education, and healthcare all through their computers or smartphones at home. The SolarWinds cyber attack of 2020 is just one of many notable cyber attacks that have recently occurred. While cyber criminals are still targeting individuals, it appears that attackers are starting to shift their efforts more toward organizations and government agencies in order to gain larger financial benefits from each individual attack. Within Texas, school districts have specifically been targeted by cyber attacks; the state passed the Texas Cyber Security Act in 2017 to address some of these issues. More recently in 2021 additional cybersecurity programs were introduced through Texas Senate Bill 475, which includes funding for Endpoint Detection and Response Technology, among other programs. The IIJA, passed in 2021, includes $1.9 billion in funding for cyber security to be implemented across numerous programs. A large portion of the funding is earmarked for state and local government IT network modernization.

## Recommendations

Based on updates over the past couple of years, opportunities for advancing the technology in the short- and long-term include the following:

***Short-Term***

- Continue to track federal, state, and local data privacy legislative efforts.
- Track the implementation and enforcement of the California Consumer Privacy Act.
- Explore joint data procurement opportunities.

***Long-Term***

- Continue to invest in big data and predictive data analytics projects.
- Prepare a data strategy for the influx of CAV data and other emerging datasets.
- Invest in and plan for more advanced cyber security needs.

# Deep Dive: Mobility-as-a-service

# MOBILITY-AS-A SERVICE

Mobility-as-a-service (MaaS) technology is a streamlined platform where users have the ability to plan routes and pay for trips with the access to all mobility providers available nearby. MaaS technology has not advanced significantly in recent years; while some countries have deployed operating MaaS platforms, domestic platforms continue to evolve.

**Maturity Scale**

**Concept** — **Operational**

## KEY TAKEAWAYS

**Short-Term.** Because MaaS requires the coordination and cooperation of operations in and outside of the mobility field, leveraging and building connections early is an important initial step to deploying a successful MaaS operation. Upon initial outreach, identify existing technologies that can be used to establish foundational MaaS operations to avoid duplicated efforts..
**Long-Term.** Consider methods for scaling MaaS platforms to reach regional mobility, and later statewide, access to work toward a singular Texas-wide mobility platform.
**Active Deployments**

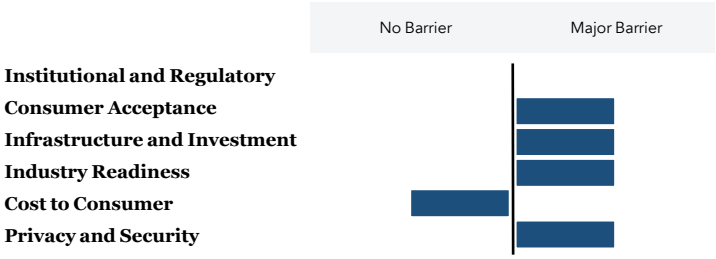
- Move PGH
- Cambridge Systematics with MnDOT
- Waymo One

| Readiness Index | Policy | Deployment | Research | Public Education |
|---|---|---|---|---|
| 7 | — | ! | ⚙ | ⚙ |

*Legend:* ! =High Priority ⚙ =Needs Work — = Not Urgent

## GOAL ALIGNMENT


## BARRIER ASSESSMENT




## USE CASES

- **Last-Mile Solutions:** MaaS offers streamlined access between primary modes of travel, like buses or rail lines, to scooters, bike-share, and other micromobility services. The "last-mile" is often one of the biggest barriers to users choosing transit options over personal vehicles and ensuring an easy-to-use and convenient transfer to micromobility providers minimizes the barrier.
- **Congestion Management:** One of the best opportunities for reducing traffic congestion is to allow roadway users a variety of mobility options, apart from driving a personal vehicle. Expanding mobility options will not convince drivers to leave their vehicles, however drivers who have a lower tolerance for traffic congestion may now utilize the opportunity of alternative mobility services than they may not have felt were feasible previously.

# Analysis: Mobility-as-a-service

MaaS is an on-demand multi-modal mobility platform where users are able to plan and pay for trips in a single streamlined channel. A comprehensive MaaS platform will integrate public transit (buses and rail lines), micromobility services (scooters and bike-share), and other available ride-share platforms, with the ability to transfer between services and pay only once. The ease and efficiency of a MaaS platform supports a cost-effective and convenient mobility network, reducing the need to rely on personal vehicles, ultimately promoting equity, reducing the potential for roadway congestion, and limiting carbon emissions. Only a small number of MaaS platforms operate today, including Whim in Finland. Efforts resembling MaaS are progressing in the US, such as the partnership of Uber and Lyft with scooter and bike-share companies that are integrated within the same platform. While efforts are slow-moving, the MaaS market is expected to grow substantially; valued at $42 billion in 2018, some estimates show market value to reach more than $372 billion by 2026.

## Deployment Challenges

The shift in travel patterns resulting from the COVID-19 pandemic may be a factor in the slow advancement of MaaS technology. The increase of opportunities to work from home and concerns over social distancing have most notably impacted transit ridership figures. While transit ridership continues to increase, figures are still significantly lower than levels seen prior to the pandemic. New York's MTA now supports roughly 18 million weekly passengers versus 36.7 million during the same time prior to the pandemic. WMATA in DC now sees 3.2 million weekly passengers versus 6 million before the pandemic. BART

in San Francisco now supports 783,000 weekly passengers versus 2.3 million at the same time prior to the pandemic. The continual growth of EVs and importance in limiting carbon emissions presents another potential challenge for MaaS deployment. Some municipalities, including Los Angeles, are setting standards to phase out the use of internal combustion engine vehicles (ICEVs), which would require all mobility providers to use vehicles that run on alternative energy. Because MaaS supports all mobility options, ensuring the electrification of the entire ecosystem must be a coordinated and collaborative effort.

### Expansion Opportunities

Despite the challenges associated with expanding MaaS platforms, many industry and legislative efforts show promise in mitigating some concerns. Stay-at-home requirements throughout the COVID-19 pandemic allowed many municipalities the opportunity to expand bike infrastructure. Secure bike infrastructure is associated with higher biking rates city-wide, reaching beyond the specific corridor or segment developed. Further, bikes and scooters support last-mile trips, where other modes of transportation may not reach. The IIJA invests billions of dollars into multi-modal transportation infrastructure to promote public transit and roadway/pedestrian safety. This funding expansion will support comprehensive transit coverage, user comfort, and other investments that will play a direct role in supporting a transition to MaaS. Lastly, industry disruptors and original equipment manufacturers (OEMs) have expanded services that reflect MaaS platforms. The first is a platform called Hitch, an app where users will pay a subscription and can easily connect with other riders traveling between cities within Texas. This is an opportunity for car-less Texans to more conveniently make longer-distance, on-demand, and even door-to-door trips, promoting equity for users who have disabilities or experience difficulty switching between transportation modes. Toyota's "Autono" platform is a set of driving kits and sensors that can be affixed to Toyota's 2022 Sienna minivan, created in partnership with May Mobility, to utilize autonomous driving for MaaS applications. Similar to Hitch, these MaaS applications can be used for on-demand and door-to-door transportation.

## Use Cases

### Urban Use Case

Move PGH is a collaborative effort that includes several stakeholders in the public and private sector. Internally, the City of Pittsburgh coordinated with the Department of Mobility and Infrastructure (DOMI) and other local mobility operators to establish the Pittsburgh Mobility Collective. The ultimate goal for Move PGH is to promote mobility opportunities beyond personal vehicles, through a streamlined and intuitive platform. Move PGH utilizes a partnership with Transit App for users to have access to all available mobility options, plan trips, and to pay. Existing operators include the existing transit offered by the Port Authority of Allegheny County, POGOH bikeshare, Spin scooters, Scoober mopeds, Zipcar car-share, carpool matching by Waze, with more partnerships planned. In collaboration with project stakeholders and a city-wide analysis of population,

equity, and transportation access, Move PGH identified a series of corridors on which to deploy "mobility hubs." Mobility hubs serve as a dedicated space where multiple mobility options are located, at sites that are easily accessible to the surrounding community and to serve as first- and last-mile mobility solutions. Twenty mobility hubs have been installed, with more planned, with the ultimate goal of improving flexibility and increasing coverage of public transit and easing the shift away from using a personal vehicle.

Move PGH is still in early stages, first collecting stakeholder information starting November of 2020 and launching the program in July 2021. Next steps include a mid-pilot report, to be available in July of 2022, a Phase 2 Mobility Hub Installation over the summer of 2022, and the final pilot report issued in July of 2023.

## Regional Use Case

Cambridge Systematics is partnering with Minnesota DOT to deploy MaaS on a regional scale in southern Minnesota to serve rural communities in the state. Still in its early stages, this partnership builds on several previous efforts within and outside of Minnesota. This project will merge two existing efforts, including the Southern Minnesota MaaS project, funded by an FTA Accelerating Innovative Mobility (AIM) Grant, and the Western Minnesota Contactless Payment project, which was created as part of a COVID-19 research grant. The goal for this merger is to allow rural and urban southern Minnesotans the ability to seamlessly plan, book, and pay for multimodal trips. This project utilizes MaaS technology from projects across the country, including GTFS-Flex in Vermont and FindMyRidePA from Pennsylvania. GTFS-Flex is an extension to trip-planning software that provides information on fixed-route, scheduled transit services, but also expands this ability to generate trips that incorporate demand-responsive services. Currently, the FindMyRidePA service is an online platform that incorporates all public fixed-route transit availability within a twelve-county region of Pennsylvania and plans to eventually expand to incorporate commercial services and other non-profit transportation services. This operation presents travelers with potential travel options, cost, and travel time estimates. Building on innovative deployments, Cambridge Systematics will partner with Transit App, Token Transit, and Trillium. MnDOT is responsible for managing this project in partnership with Minnesota IT Services. This project will be a two-year demonstration to further identify benefits and challenges in MaaS technology.

## Integration with Emerging Technology

Autonomous vehicle technology company, Waymo, has developed its Waymo One autonomous ride-hailing service. This platform has two operational deployments, in Phoenix, AZ and San Francisco, CA. Waymo One serves as an alternative for users to own personal vehicles, and more closely serves as an autonomous equipped rental vehicle. One opportunity this platform highlights is the ability to add up to five different stops on your trip, where riders can run multiple errands in a round trip. While this is only a single mode of transportation, it is an on-demand platform that serves as an alternative for personal vehicle ownership.

## Los Angeles Universal Basic Mobility

A challenge that residents face in many auto-centric cities is the drastic difference in accessibility for car owners versus those that rely on public transit. In Los Angeles it is estimated that residents are able to reach twelve times as many jobs with a car than with public transit. Los Angeles has launched its "Universal Basic Mobility" pilot program as an opportunity to promote equity to this imbalance. The pilot, launched in April of 2022, offers roughly 2,000 Angelenos in underprivileged neighborhoods a monthly stipend of $150

that can be used for public bus and train fares, as well as on-demand shuttles, scooters and e-bikes, and even EVs. Los Angeles is one of many cities worldwide that is beginning to adopt this model; Bakersfield and Oakland are two other California cities that recently launched a similar program.

## Recommendations

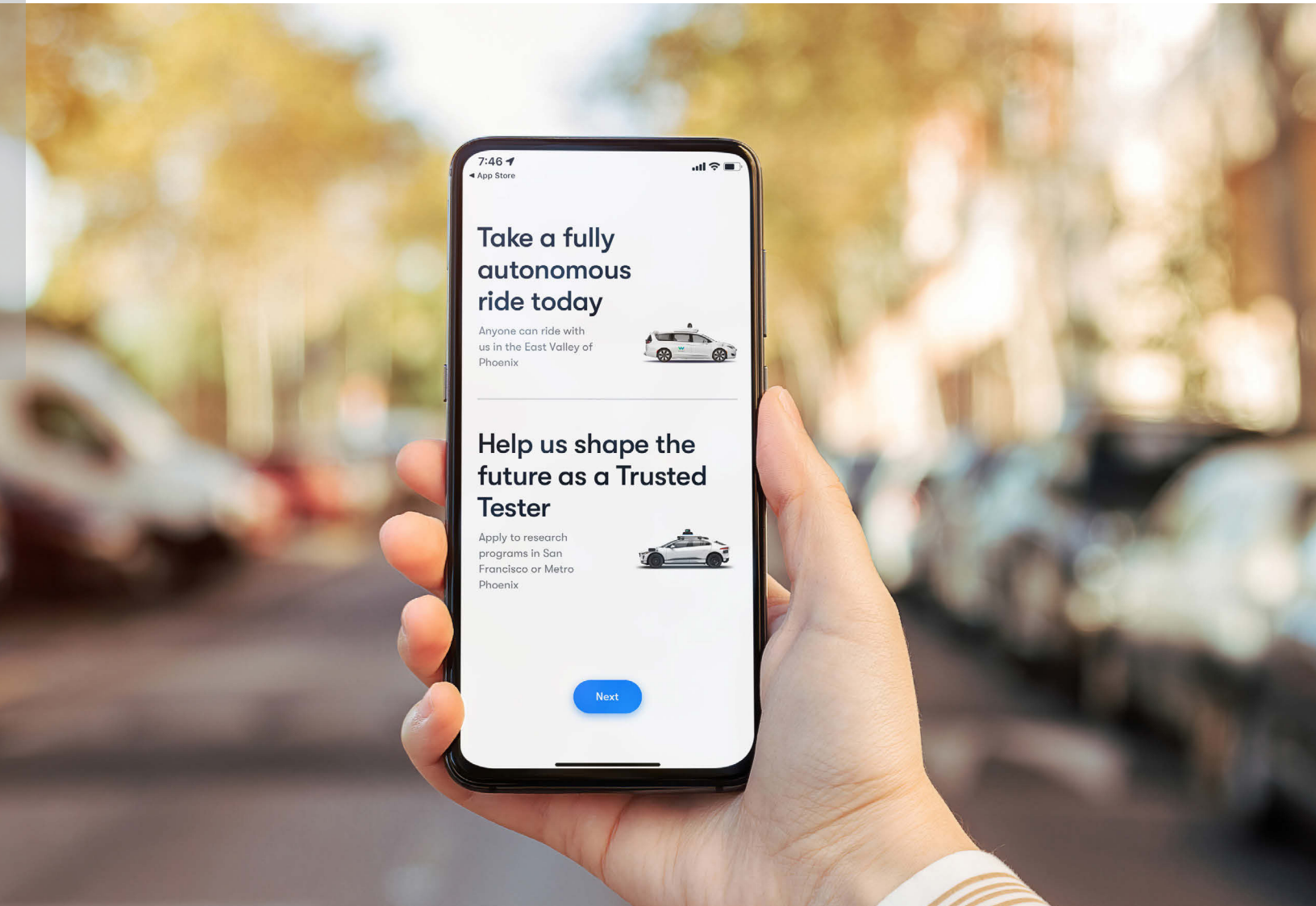
Based on updates over the past couple of years, opportunities for advancing the technology in the short- and long-term include the following:

***Short-Term***

- Coordinate with a wide range of stakeholders including mobility providers, payment operators, technology services, and user representatives.
- Identify and catalog existing MaaS adjacent programs and software that can be used to build operations and reduce unnecessary duplication of efforts.
- Since MaaS technology already exists, prioritize pilot deployments and work to evolve and scale as technology and standards improve.

***Long-Term***

- Plan coordination among mobility providers across Texas to work toward a large-scale regional or state-wide MaaS platform.
- Observe technology advancements in cryptocurrency, the blockchain, and digital identity as an opportunity to evolve MaaS technology integration.
- Evaluate success on equity and mobility access metrics to evolve the MaaS platform.



# CONCLUSIONS

Texas continues to change. Its population is urbanizing, aging, diversifying and growing at an unprecedented pace. The effects of the COVID-19 pandemic are still rippling through communities with impacts on travel behaviors including demand shifts that hit differently by time of day and geography. As global forces such as oil supply constraints and online shopping lag, supply chains and the freight sector strive to keep up. With renewed interest in electric vehicles and mitigation of severe weather events being prioritized by federal agencies, state and local communities are undertaking programs and activities to shift to new technologies.

The challenges and changes over the past three years have become clear, and now the opportunities for innovation are coming into focus. Technologies like automated and connected vehicles may be able to improve safety and accessibility and add capacity to the freight transportation sector. Electric vehicles present opportunities for economic development and environmental stewardship. In urban areas, big data and mobility-as-a-service give rise to accessibility and new mode choices that may facilitate opportunities for education, employment, and critical services.

The Texas Technology Task Force remains committed to identifying opportunities and barriers to technology maturation and adoption. The continued activities of the Task Force and the planning documents such as the Technology Utilization Plan will synthesize technology discovery efforts, compile lessons learned, and streamline guidance to TxDOT and other stakeholders.


# References


1. Potter, L. et. al., (2021, April). Texas Household Trends and Projections, 2010-2050. Texas Demographic Center https://demographics.texas.gov/Resources/publications/2021/20210415_HouseholdsTrendsProj_Brief.pdf?dt=20200922
2. Potter, L., (2022, February 7). Demographic Trends and Transportation. Texas Demographic Center. https://demographics.texas.gov/Resources/Presentations/OSD/2022/2022_02_07_2022TexasTransportationForum.pdf
3. Manjoo, F., (2021, November 23). Everyone's Moving to Texas. New York Times. https://www.nytimes.com/2021/11/23/opinion/move-to-texas.html?searchResultPosition=3
4. Texas Demographic Center, (2016, June 7). Aging in Texas: Introduction. https://demographics.texas.gov/resources/publications/2016/2016_06_07_aging.pdf5
5. Potter, L. Demographic Trends and Transportation
6. https://www.newsnationnow.com/morninginamerica/congestion-here-to-stay-but-covid-changing-traffic-patterns/
7. https://www.txdot.gov/inside-txdot/media-center/statewide-news/006-2022.html
8. https://tti.tamu.edu/researcher/shipping-stranglehold-pandemic-hampered-business-operations-and-supply-chains-in-texas/
9. https://comptroller.texas.gov/economy/fiscal-notes/2022/jan/tour.php
10. https://abc13.com/port-houston-seeing-high-imports-during-pandemic-more-cargo-ships-in-backups/10407614/
11. https://www.theverge.com/2022/7/13/23207428/tesla-texas-ev-charging-heatwave-off-peak-grid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