Chapter 3

Factors and Trends

What Can the Region Expect over the Next 20 Years?

The core of *Resilience 2050* is a list of major projects and programs the region intends to implement over the next 20+ years, given the amount of funding reasonably expected to be available. We did not develop this list in a vacuum. Many factors and trends—some known, some anticipated and some unknown at this time—will affect the regional transportation network in the future.

This chapter discusses some of these factors and trends. The goal of this discussion is to provide additional context so that readers can better understand why we made certain decisions, as well as how those decisions might better prepare the region to respond to the uncertainties of the future.

Environmental Issues and Challenges

Chapter 1 of this plan describes the federal requirements the region must meet to maintain conformity with national air quality standards. Besides these air quality conformity issues, the region faces several other environmental challenges.

Greenhouse Gas Emissions and Climate Change

There is a strong link between growth in vehicle miles traveled (VMT) and greenhouse gas (GHG) emissions from the transportation sector. According to the Maryland Department of Transportation's (MDOT) [2020 Greenhouse Gas Reduction Act Plan](), statewide VMT has been steadily increasing since 2014, with over 60 billion VMT in 2019. While VMT dropped dramatically in 2020 due to the

COVID-19 pandemic, MDOT anticipates that VMT will rebound back to 2019 levels over the next few years. According to projections by the Maryland Department of Planning (MDP), Maryland may grow to over 6.5 million people by 2030. Coupled with economic expansion and land use changes, VMT could increase to over 69 billion by 2030.

More miles traveled directly equates to the combustion of more gallons of fuel and the release of carbon dioxide. Emissions of carbon dioxide, a key GHG, result from the burning of fossil fuels such as gasoline and diesel fuel. Transportation accounts for thirty-five percent (35%) of emissions in the state, and represents the largest source sector for GHGs in Maryland. Environmentally conscientious planning must consider the implications of potential long-term climate change and the role that vehicle emissions play. GHG emissions that result from human activity contribute to global warming, which is the increase in average global temperature.

Climate Projections for the Region

Temperatures are projected to increase dramatically in the Baltimore region over the coming decades. For example, average temperatures could rise by nearly 5°F by mid-century. The region is also projected to experience approximately 66 days above 90°F and six heatwaves annually by mid-century. As temperatures warm, the number of days below freezing also

Over the past century, the climate has been changing in the Baltimore region:

> **Increasing temperatures:** Annual temperature in the region has increased by 0.2°F per decade; there is a clear upward trend since 1895.

> **More intense storms:** Annual precipitation in the region has increased slightly over the past century. More of this precipitation has been falling in intense storms.

> **Nuisance flooding and sea level rise in the Chesapeake Bay and its tributaries:** This is due to slowly sinking land as well as warming oceans. Relative sea level, measured at the Annapolis tide gauge, has risen by 1.22 feet from 1928 to 2020. Flooding from high tides, also known as nuisance flooding, occurred fewer than 5 days per year in Annapolis in the 1950s but now occurs more than 40 days per year.

will decrease significantly. Each jurisdiction within the region will experience similar projected changes. However, areas along the Chesapeake Bay will continue to be warmer compared to the inland areas. Figure 1 depicts projected increases in annual average temperatures in the Baltimore region.

More extreme precipitation events are likely to occur in the Baltimore region over this century. Both the 24-hour, 10-year and 100-year rainfall events[1] are projected to be heavier, but overall average annual precipitation is not projected to increase notably. For example, annual precipitation is expected to increase by about 3 inches by mid-century. The projections indicate more precipitation falling in heavy events within a single day or consecutive days. The projected

[1] A 10-year rainfall event is defined as a rain storm with an amount of rain that is equaled or exceeded once every 10 years. A 100-year rainfall event is defined as a rain storm with an amount of rain that is equaled or exceeded once every 100 years. A 100-year rainfall event is more extreme than a 10-year event.

Figure 1- Annual average temperatures across the Baltimore region*

*Projected values represent the median result from 32 models for the Regional Concentration Pathway (RCP) 8.5 scenario. RCP 8.5 is one of several climate modeling scenarios adopted by the Intergovernmental Panel on Climate Change and is the scenario used by the Federal Highway Administration. It represents a projected estimate of the concentration of greenhouse gases in the atmosphere; RCP 8.5 assumes a low level of effort to curb emissions.

Figure 2 - Rainfall during extreme events*

Precipitation (inches)

■ 24-hour, 100-year rainfall amount   ■ 24-hour, 10-year rainfall amount
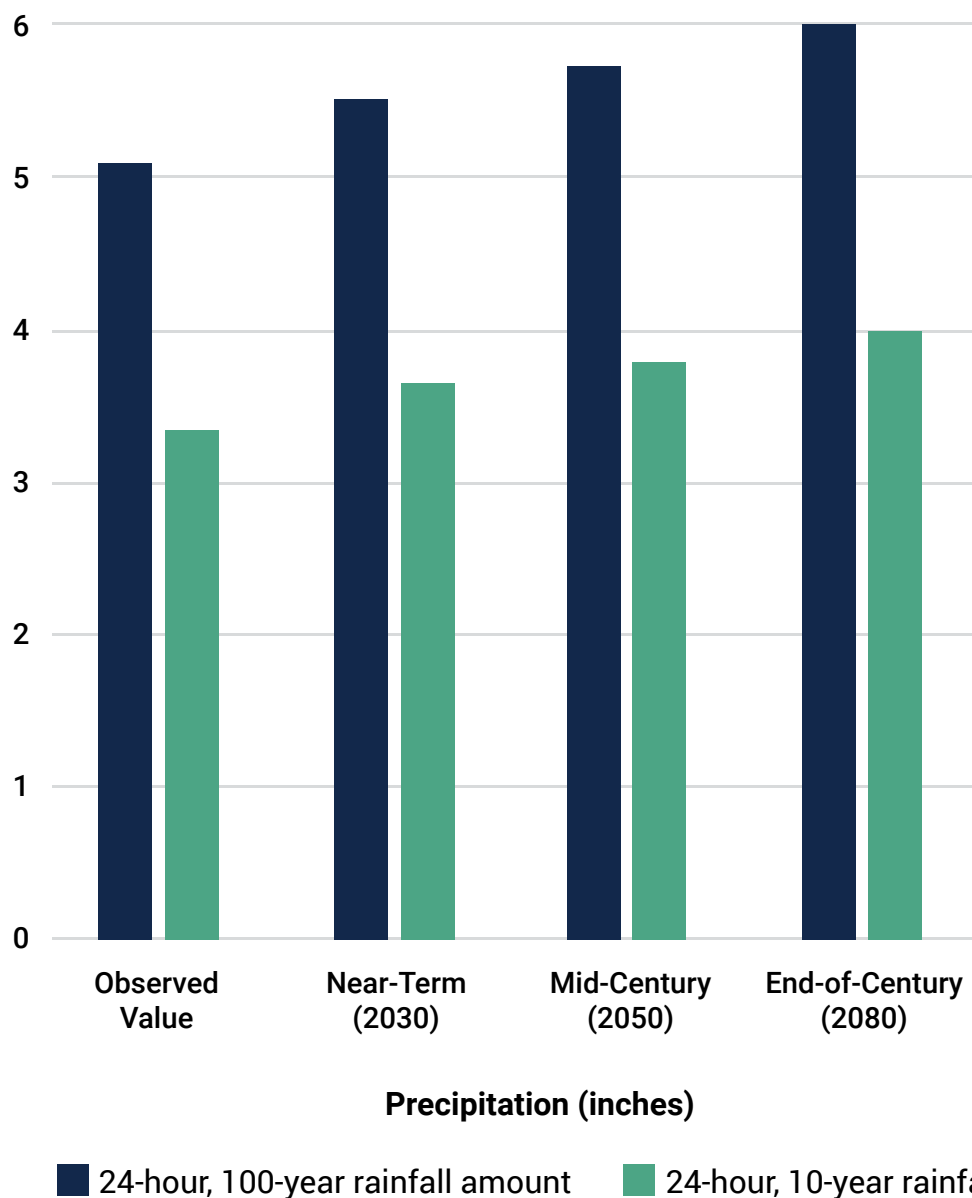
* All projections shown are for RCP 8.5.

changes will be similar across each jurisdiction. The northern part of the region will continue to experience greater annual precipitation relative to the southern portion. Precipitation increases are expected only during certain parts of the year. Precipitation is projected to increase in the winter and spring months, and stay relatively similar during summer and fall months. Figure 2 summarizes the shifting rainfall patterns expected within the region.

More extreme precipitation events are likely to occur in the Baltimore region over this century. Projections indicate more precipitation falling in heavy events within a single day or consecutive days.

Table 1 - Projected relative sea level rise at local tide gauges*

Tide Gauge	Projected Relative Sea Level Rise (ft)		
	Near-Term (2030)	Mid-Century (2050)	End-of-Century (2080)
Baltimore	0.6 (0.4 – 0.9)	1.2 (0.8 – 1.6)	2.3 (1.6 – 3.1)
Annapolis	0.6	1.2	2.4

* Values shown are the state of Maryland's projected sea level rise values above 2000 levels. The projected value represents a central estimate, or the 50% probability that sea level rise is projected to meet or exceed. Values in parentheses indicate the likely range of projected sea level rise; sea level rise has a projected 67% probability of being between these values (not specified in the data source for the Annapolis tide gauge). The 2030 and 2050 projections for sea level rise are for RCP 4.5, though there is very little difference between RCP 4.5 and RCP 8.5 over the next 30 years. The 2080 projections are for RCP 8.5. Source: Sea-level rise: Projections for Maryland 2018.

Sea level rise will significantly affect the Baltimore region shoreline, as summarized in Table 1. Maryland's coastline will experience minor differences in sea level rise across locations due to local differences in vertical land movements. Scientists determine relative sea level rise based on data from tide gauge stations in the Chesapeake Bay; two of these stations are located in the Baltimore region.

As sea levels rise and storms become more intense, the depth and extent of flooding from storm surges are also expected to become more severe.

Interactive maps for the entire Baltimore region showing inundation depth under different sea level and storm scenarios are available in the interactive MDOT SHA Climate Change Vulnerability Viewer.

Importance of Regional Resilience Efforts

For many years, our work has included reducing emissions and improving air quality. More recently, work has expanded to include adaptation, such as the Climate Change Resource Guide and follow-up recommendations for its implementation and for enhanced inter-jurisdictional coordination on resilience. Regional resilience efforts related to transportation will continue to be closely linked to and supportive of local and state work.

With a renewed focus on climate change and resilience at the national level, there are various new programs and sources of funding, such as through the Infrastructure Investment and Jobs Act (IIJA) and other programs, that directly support enhanced resilience. We will work with public and private partners to apply these programs as appropriate.

Chesapeake Bay

The Chesapeake Bay watershed includes six states and spans 64,000 square miles. There are excess amounts of nutrients (nitrogen and phosphorus) and sediment being deposited into the Bay. Sources of these pollutants include agriculture, urban and suburban runoff, wastewater and atmospheric deposition. Downstream effects of excess nutrients and sediment include loss of water clarity and algal blooms. These create conditions that are harmful for fish, shellfish and other underwater life. For example, algal blooms can block sunlight from reaching underwater grasses and create low-oxygen "dead zones" during decomposition that can suffocate marine life.

The U.S. Environmental Protection Agency (EPA) issued a "pollution diet" in December 2010 across the entire Chesapeake Bay as well as each tidal segment. This pollution diet is in the form of a Total Maximum Daily Load (TMDL), with caps set on levels of nitrogen, phosphorus and sediment going into the Bay. TMDLs are Clean Water Act regulatory tools that set daily limits on pollutants going into water bodies. There are a series of accountability measures to ensure the TMDL caps are being met.

In August 2019, Maryland published the Phase III Watershed Implementation Plan (WIP). This plan is designed to achieve Maryland's 2025 Chesapeake Bay TMDL pollution targets. Urban stormwater runoff includes runoff from roadways. There are a number of different ways to mitigate the effects that roadways have on stormwater runoff pollution, including grass swales, bioswales, stormwater management ponds, infiltration trenches, submerged gravel wetlands, wet swales, sand filters, bioretention, stormwater wetlands, stream restoration, tree planting and street sweeping.

Different aspects of climate change are predicted to hinder efforts to clean up the Chesapeake Bay. Increased runoff and rainfall events from climate change could affect the Bay through increased erosion and sediment loads. As a result of the potential for climate change to affect water quality in the Chesapeake Bay, the state submitted to the EPA an addendum to the Phase III WIP to address additional load reductions required in order to meet TMDL endpoint goals by 2025.

Environmental Issues and Challenges and *Resilience 2050*

Resilience 2050 demonstrates the high priority placed on environmental issues and challenges through regional goals and strategies focused on implementing environmentally responsible transportation solutions (see Chapter 4) and through the project scoring methodology. The technical project scoring methodology includes 10 technical scoring points related to environmental conservation, amounting to approximately 20 percent of total technical scoring points. The criteria focus on effects on ecologically sensitive lands and culturally significant resources (5 points) and potential for GHG emissions reductions (5 points). A subset of these points focus on anticipated environmental impacts on low-income and minority populations.

Why active transportation is important to the region:

- Air Quality
- Equity
- Health
- Safety

Active Transportation Factors and Trends

Active transportation is critical to the Baltimore region's transportation system and includes bicycling, walking and using electric scooters, electric bicycles and wheelchairs. Almost all trips begin or end with some form of active transportation, including trips made using motor vehicles or transit. Most of us use active transportation on a weekly if not daily basis.

A connected and safe active transportation network benefits the Baltimore region by improving equitable access to destinations that meet the daily needs of a diverse group of users. This can include connections to transit systems, schools, jobs, housing, core services, parks and more. Broadening transportation choices and increasing active transportation use can increase job opportunities, physical activity and economic competitiveness while providing tourism opportunities and reducing motor vehicle traffic and associated emissions.

This section focuses on some of the factors and trends related to active transportation, including the demand for connected networks of active transportation facilities for all ages and abilities, the safety of active transportation users, connections between transit and active transportation, equity considerations, public health and economic competitiveness.

Connected Network of Active Transportation Facilities for All Ages and Abilities

A network of well-connected active transportation facilities that appeals to people of all ages and abilities has the potential to increase bicycle and pedestrian rates. Research has shown that the perception of comfort or traffic stress affects a person's decision to bicycle, walk or use a scooter. Guided by the 2040 Maryland Bicycle and Pedestrian Master Plan 2019 Update, MDOT recently completed a [Maryland Bicycle Level of Traffic Stress (LTS) analysis](#) of all roadways and bicycle facilities in the state. The LTS analysis identifies how comfortable a bicycle facility or roadway is based on a

number of factors. This analysis will allow us to identify and address gaps in the regional bicycle and shared-use network that are currently uncomfortable for most users with the goal of creating a network that is appealing and comfortable for all ages and abilities.

The Baltimore region sidewalk inventory, currently under development, will bring Baltimore region jurisdictions much closer to having the necessary data for a pedestrian LTS analysis. Pedestrian LTS analysis of a geographic area allows for identification of gaps for pedestrians in the active transportation network and aids in identification and prioritization of projects.

Shared-use paths are separated from the roadway and can be used by walkers, bicyclists, wheel chair users and e-scooter users. Bicycle lanes are dedicated lanes on the roadway for use by bicyclists and e-scooter users and can include painted separation from motor vehicle lanes or physical barriers such as a curb, median, parked cars, a landscaped strip or other type of barrier.

Safety

Non-motorist or pedestrian, bicycle and scooter user safety is a priority for us, MDOT and member jurisdictions. Serious and fatal crash rates for drivers and active transportation users are on the rise in the Baltimore region, reflecting national trends. Non-motorists make up a disproportionate share of serious and fatal crashes. Crashes involving non-motorists made up 3.8 percent of all crashes in the Baltimore region in the five years from 2016-2020. However, they accounted for 28.6 percent of all fatalities and 9.3 percent of all injuries.

We are dedicated to understanding the causes of crashes and identifying appropriate and effective safety countermeasures. Safety planning is a critical component of the LRTP as most safety infrastructure projects and awareness programs take many years to create change. The Transportation Improvement Program (TIP), which is focused on projects funded over the next four fiscal years, also incorporates safety in evaluation criteria.

Agencies across the country are focusing on eliminating fatal and serious injury crashes through data-driven systemic approaches including integrating safety into the project selection process and plans at all levels. Strategies include supporting projects that use the Safe System Approach to increase safety for all and advancing Complete Streets and Vision Zero approaches. We work closely with partners at MDOT SHA, MDOT Motor Vehicle Administration and Maryland Highway Safety Office.

Transit

Active transportation and public transit make natural partners as public transit riders often walk, bicycle or use e-scooters or e-bicycles to and from their transit stops. Active transportation travel is well suited to bicycling trips of less than six miles and walking trips of less than one mile. Access to transit expands the reach of active transportation travel throughout a region and beyond. Nationally and regionally, agencies have focused on improving active transportation facilities within walking, bicycling and scooting distance of transit access and on coordinating with transit providers to ensure that active transportation can be combined with transit for longer regional trips.

We will continue to support the efforts of local and state partners to increase active transportation access to transit. In 2022, we approved the Transportation and Land Use Connections (TLC) program, which provides support to member jurisdictions in the form of an annual competition for grants. Funded projects include the planning and preliminary design of shared-use paths and separated bicycle lanes that improve connections to transit stops. We will continue to collaborate with our local and state partners to identify and address gaps in the bicycle and pedestrian network around transit stops.

Equity

A connected active transportation network is critical for linking community members of all ages and abilities to core services and amenities, especially those who walk or bicycle out of necessity rather than choice. The uneven distribution of high quality active transportation and transit access can affect the safety, mobility, health and economic opportunities of vulnerable communities. Nationally, lower income communities of color are overrepresented in bicycle and pedestrian crashes.

Several of the scoring criteria for projects submitted for inclusion in the LRTP include equity components. For example, the Complete Streets technical scoring criteria includes an assessment of the inclusion of Complete Streets features and the project's impact on improving accessibility for low-income and minority populations.

Complete Streets includes planning, designing and operating roadways so they are safe to use and support the mobility of users of all ages and abilities. Examples include sidewalks, protected bicycle lanes, public transportation stops, curb extensions and reduced speed limits.

Equity is also incorporated in our projects and assessments through the [Vulnerable Population Index](#) (VPI). The VPI allows us to identify areas with concentrations of seven groups determined to be vulnerable based on an understanding of federal requirements and regional demographics. These populations have historically been underserved by the transportation system and may face challenges to accessing employment and core services.

Public Health

Research has shown that bicycling and walking can assist people in meeting recommended levels of physical activity and potentially improve public health due to the health benefits of increased physical activity. A well-connected and comfortable active transportation network can increase access to recreational areas and parks. Replacing a vehicle trip with biking, walking or scooting also reduces greenhouse gas emissions that contribute to poor air quality. However, walking and bicycling rates are impacted by the presence or lack of sidewalks and other pedestrian infrastructure, bicycle lanes, shared-use paths and bicycle boulevards.

We have supported the efforts of member jurisdictions in planning Bike to Work Week in the Baltimore region, which celebrated its 25th anniversary in 2022. Bike to Work Week is a campaign celebrating bicycling as a healthy and affordable commuting option while promoting public awareness of its safety and environmental benefits. Bike to Work Week

helps raise awareness of the rules of the road for drivers, pedestrians and bicyclists, and also highlights the need to improve bicycle facilities to improve safety.

Economic Competitiveness

A thriving regional economy is tied to improved job opportunities, social mobility and strong communities. Impact reports of trails networks have shown that active transportation and recreation can support a region's competiveness, as they are valued by existing and potential residents and visitors. A connected active transportation network can support a region's sustainability and resilience while encouraging tourism and spending in businesses nearby. Destination active transportation trails such as the Great Alleghany Passage in western Maryland and Pennsylvania can be particularly popular draws for tourists.

Active transportation infrastructure can increase the value of nearby properties and in turn increase the demand for and vitality of communities. However, rising property values can raise issues of affordability and potential displacement. There is a national discussion about the role of communities and policymakers in mitigating the risks associated with rising property values. An expanded regional active transportation network could increase the Baltimore region's economic competitiveness, sustainability and resilience, encourage tourism and increase the appeal of communities. However, the region will need to continue to discuss equity issues associated with a potential rise in property values.

Active Transportation and *Resilience 2050*

There is an increasing interest in a regional network of active transportation facilities that is comfortable and safe for all ages and abilities. The Baltimore region has over 300 miles of shared-use paths and over 200 miles of bicycle lanes. These numbers continue to increase annually as local jurisdictions and MDOT SHA work to realize the design and construction of planned bicycle and shared-use facilities.

We will continue to collaborate with local and state members to coordinate and promote active transportation planning in the Baltimore region. The IIJA significantly increased federal funding for active transportation and the safety of vulnerable road users. Our work, and that of our regional partners and the state to coordinate on active transportation projects and policies, places the Baltimore region in a strong position to leverage this increased funding to expand the region's active transportation network and improve safety.

The project scoring process for *Resilience 2050* includes additional points for projects

Specific actions we are taking include:

> Continuing to dedicate support to active transportation-related projects such as:
  - Developing a vision for a regional network of bicycle and shared-use facilities improving regional connectivity, safety and mobility.
  - Leading preliminary design of additional segments of the Patapsco Regional Greenway (PRG) and other shared-use facilities.
  - Managing the development of concept plans of pedestrian and bicycle infrastructure improvements.

> Providing staff support to the Bicycle and Pedestrian Advisory Group (BPAG), a subcommittee made up of representatives from member jurisdictions and the state which promotes the sharing of information and ideas for improving active transportation in the region.

> Continuing bicycle and pedestrian counts throughout the region such as counts conducted before and after a project is constructed and to assess a location under consideration for long-term counter installation.

> Tracking the deployment, management and advancing technology of micromobility in the region to assist member jurisdictions in taking advantage of its benefits while minimizing potential downsides.

> Supporting the inclusion of Complete Streets and active transportation projects in the LRTP and TIP.

incorporating Complete Streets features. Approximately 90 percent of the projects in *Resilience 2050* include some Complete Streets features, with 65 percent including Complete Streets features throughout the majority of the project. These features range from reduced speed limits and bicycle and pedestrian facilities to mid-block crossings and crossing treatments such as High-Intensity Activated CrossWalk (HAWK) signals. Approximately 70 percent of the *Resilience 2050* projects include pedestrian and bicycle facilities such as sidewalks, mid-block crossings, ADA improvements, shared-use paths and bicycle lanes.

We also approved inclusion of a list of top active transportation projects totaling more than 175 miles of bicycle and pedestrian facilities in *Resilience 2050* under set-aside funding. The $250 million in set-aside funding is included in *Resilience 2050* to encourage programs and projects that reduce emissions due to the Baltimore region's nonattainment status for air quality. See Chapter 7 for a summary of set-aside funding and the full list of top regional active transportation projects.

Transit Factors and Trends

Robust transit moves people to their destinations in an efficient, affordable way. Public transportation systems in the greater Baltimore region include buses, trains, ferries, light rail transit, bus rapid transit, paratransit and metro services that are available for use by the public and generally run on a scheduled timetable.

Planning for the development of new or expanded transit service in the urban, suburban and rural communities that make up the greater Baltimore region should take into consideration its wide-ranging benefits. Public transportation systems create a groundwork on which our communities may thrive – becoming healthier, more livable and more prosperous in a number of ways.

Public transportation supports residents, businesses and communities in our region by helping to provide connections

to jobs, education, family and friends, recreation, healthcare and other services. Transit services that connect people to their destinations in the urban, suburban and rural cores of our region contribute to community vitality, help create a more equitable transportation system, improve air quality, foster economic growth and support better health outcomes for an improved quality of life.

Why transit is important to the region:

- Better health
- Cleaner air and reduced greenhouse gas emissions
- Improved mobility
- A more equitable transportation system
- Economic benefits to the community
- Improved commuter productivity

Transit in the Baltimore Region

Prior to the pandemic, nearly 300,000 public transit trips via bus and rail and 9,000 paratransit trips were taken daily throughout our region (MDOT MTA, 2020). Although factors such as ongoing patterns of working from home and staff shortages have significantly affected transit ridership, recovery has slowly begun. Overall, transit trips make up approximately 3 percent of trips by all modes of travel in the Baltimore region, led by the urban and suburban activity centers.

Multiple transit operators at the state, county and private levels serve the greater Baltimore region, providing both fixed route and demand-response service. MDOT MTA operates:

- local service and commuter service within the Baltimore region;
- service to Union Station in Washington, DC via MARC;
- connections to other transit modes including Amtrak and Greyhound;
- connections to other origins/destinations outside of the Baltimore region.

Additionally, services provided by the region's Locally Operated Transit Systems (LOTS) provide some supplemental service within jurisdictional boundaries in Anne Arundel, Baltimore, Carroll, Howard, Harford and Queen Anne's counties and Baltimore City. One regional provider includes service to multiple counties. While the majority of transit services in the region collect fares from passengers, some local services are free to riders.

Transit agencies in the Baltimore region and across the United States have struggled with decreased ridership, difficulties with operator hiring and retention, and other challenges to operations as a direct result of the COVID-19 pandemic. However, these struggles also provide an opportunity for transit agencies to develop new solutions to increase ridership, improve operations and plan for improved access for those who need it most.

Equity

While the greater Baltimore region is home to 45 percent of the state's population and 51 percent of the state's jobs, a commute to work by transit currently takes, on average, 71 percent longer than by personal vehicle. While the COVID-19 pandemic caused a dramatic drop in transit ridership, essential workers and workers with low incomes continued to rely on public transportation. However, many destinations in the region are still inaccessible by transit, and residents without access to cars or other affordable transportation modes are likely to have reduced access to jobs and services. Any planning for new or enhanced transit service should include an evaluation of equitable access to opportunities including jobs, recreation, schools and health care, as well as differences in access times by transit modes.

Transit Ridership

Public transit ridership has not made a steady recovery. Ridership levels have rapidly risen and fallen in response to COVID-19 levels across the country. Traditional weekday commuter service has seen some of the most dramatic decreases in ridership. Emerging commuter patterns as office workers keep hybrid schedules, a preference for mid-week office days, travel demand at peak hours, and car traffic bouncing back from the lows of 2020 have created unpredictable conditions. Such rapid changes and fluctuations have often made it difficult for transit agencies to keep up with service needs to connect the greatest number of riders to their destinations in this current era. To attract more riders, some transit agencies have responded by adjusting bus and subway routes and service, offering less service during historic rush-hour times and more service at other times to locations such as medical appointments, highly trafficked areas or sports and entertainment events.

Fare Policies

Frequent, reliable service with few transfers may make public transit more appealing to drivers. Since the onset of the pandemic, revised fare structures and simplified fare structures have been gaining in popularity, especially among transit networks that have adopted smart fare collection systems. These systems make it easier to cap fares and/ or offer fare free service to specific populations. Some LOTS in the region have offered reduced prices or temporary free fares to better serve lower-income communities and essential workers, as well as to attract new suburban commuters. Offering flexible and discounted mobile options for paying fares not only improves equitable access, but also may simplify the overall rider experience.

Microtransit

One of the goals of the Statewide Transit Plan is to provide fully accessible transit for people of all cognitive and physical abilities. In some areas throughout the region, in part due to a shortage of drivers, there are evening and weekend service gaps, lack of service to some locations, or the need to make reservations during operating hours well in advance. Various service providers have been exploring the potential to mix fixed routes and microtransit service to create a stronger transit network. For example, buses may provide high frequency, all day service on core routes, complemented by microtransit in areas on the edge of the core service

area. Microtransit could potentially help ridership grow to complement fixed route levels, or serve areas that do not warrant fixed route frequency, particularly in rural areas. Microtransit pilots across the country have demonstrated great promise in filling such gaps.

Funding

Nearly all transit funding in the Baltimore region comes from either federal or state government sources. MDOT MTA is the only direct recipient of federal transit grant funding, and in turn allocates all such funding and provides technical assistance to the LOTS as sub-recipients. Much of existing transit budgets in the Baltimore region are currently committed to operating and maintaining the current transit system and its infrastructure. Unlike other peer states, local jurisdictions in the region do not have formal input on budgeting and allocation decisions, and also do not contribute substantial funds to transit through taxes or other means. As a result, implementation of new strategies, expanded services and capital projects may require either new funding sources or the reallocation of existing funds. Equitable prioritization based on the greatest needs in the state after MTA fulfills other obligations around the state may also be required, particularly in the Maryland portion of the Washington Metropolitan Area Transit Authority (WMATA) service area.

Transit and *Resilience 2050*

We work together with our local and state members in coordinating and promoting transit and human service transportation planning in the Baltimore region, and in providing technical support to these providers through an array of studies and tasks.

Implementation is underway on a number of the strategies identified in the Regional Transit Plan for Central Maryland, including the first of the 30 Regional Transit Corridor studies identified in the plan. MDOT MTA is leading evaluations of two early opportunity corridors including an East-West corridor between Ellicott City and Bayview and a North-South corridor between Towson and downtown Baltimore. In 2022, BMC completed a pilot feasibility study that included an assessment of land use and zoning updates that would support the development of transit, as well as an early screening against potential funding source requirements. This pilot serves as a model for continued regional priority corridor feasibility studies.

We will lead several technical and skills development tasks to support the LOTS and MDOT MTA bus modes. Current projects in our work program include a task to identify common regional data standards and needs, partnership with MDOT MTA and the Transportation Association of Maryland to implement trainings and the development and maintenance of a regional transit dashboard.

More than 30 transit projects were submitted for inclusion in *Resilience 2050*, all of which were selected for the preferred alternative. See Chapter 7 for further details on transit projects in *Resilience 2050*.

Highway Safety Factors and Trends

From 2016-2020, the number of traffic fatalities continued to increase both nationally and in Maryland. While the U.S. showed an increase of close to three percent during those years, Maryland and Baltimore region traffic fatalities increased approximately nine percent. Beginning in 2020, likely correlated with the onset of the COVID-19 pandemic and associated safer-at-home guidelines, national fatalities increased to 38,824, a seven percent increase from 2019. From 2019 to 2020, fatalities in Maryland and the Baltimore region increased to 573 (up 7.1%) and 248 (up 19.2%), respectively. VMT decreased significantly in 2020, pushing the national fatality rate to 1.34 and the Maryland fatality rate to 1.11 deaths per 100 million VMT.

Figures 3 and 4 show the Maryland and Baltimore region fatality trends for that period to illustrate the

Figure 3 - VMT (in millions) and Fatalities in Maryland
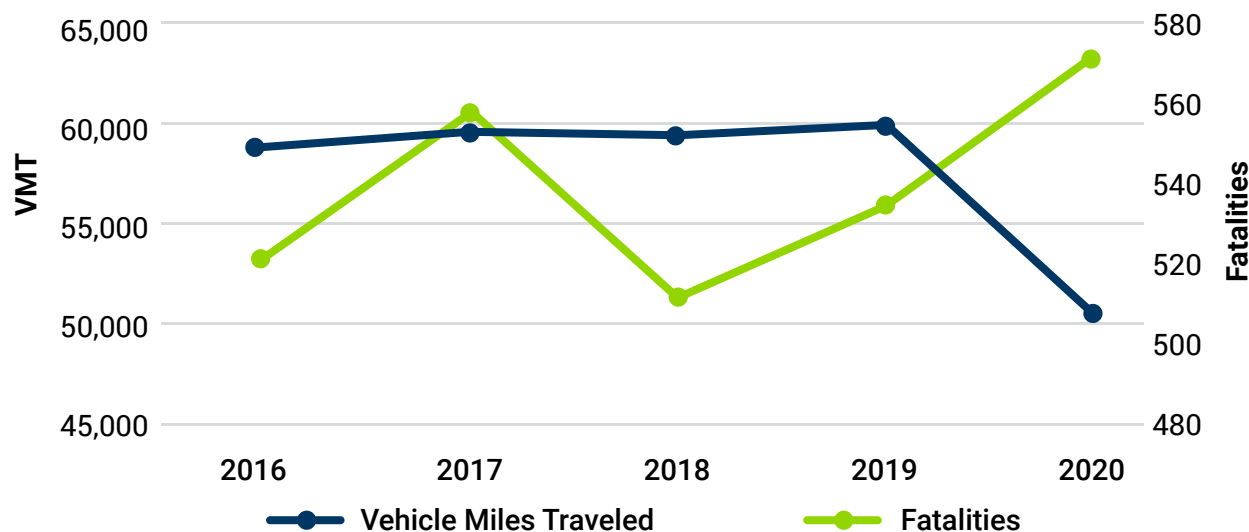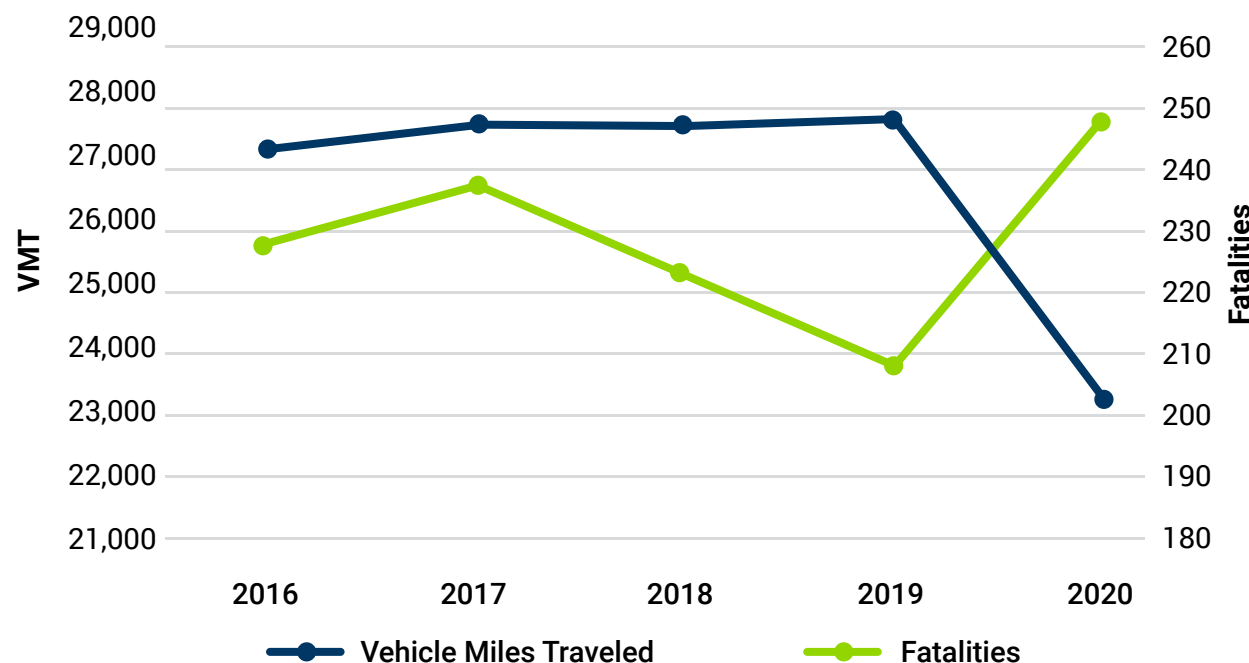

Figure 4 - VMT (in millions) and Fatalities in the Baltimore Region

decrease in VMT and associated increase in fatalities. Maryland saw a 15.9% decrease in VMT and 7.1% increase in fatalities from 2019-2020. The Baltimore region saw a 16.3% decrease in VMT and 19.2% increase in fatalities from 2019-2020.

Looking more closely at the 2021 crash report data from the Maryland State Police, approximately 79 percent of Maryland fatal crashes occurred on state-maintained roadways, close to 76 percent were vehicle occupants (drivers and passengers), 30 percent involved an alcohol/drug-impaired driver, close to 17 percent involved speeding and one-quarter of all fatalities were a non-motorist. The state observed seat belt use rate was 91.4 percent. However, about 26 percent of all fatalities were unrestrained vehicle occupants.

Several contributing trends have remained constant for many years: impaired driving, non-motorists and speeding. These continue to be significant safety concerns throughout the Baltimore region and new legislation, innovative technologies and planning will have an effect on the associated fatalities. In 2022, Maryland voters approved the legalization of marijuana for recreational use (to begin July 1, 2023), which is anticipated to lead to an increase in impaired driving. Capabilities of connected and autonomous vehicle technology continues to advance and become more common among newly purchased vehicles, which will reduce the likelihood of a crash, injury or fatality (see the emerging technologies section of this chapter for more information on connected and autonomous vehicles).

Vulnerable Road Users/Non-motorists

Non-motorists (pedestrians, bicyclists, non-vehicle occupants) are the most vulnerable users of the roadway network since they lack a physical structure for protection. In Maryland, over 20 percent of all traffic-related fatalities are non-motorists and, over the last five years (2017-2021), an average of 30 percent of the Baltimore region's traffic fatalities were non-motorists. This alarming issue has many contributing factors including but not limited to higher travel speeds and an increase in larger, heavier vehicles during a time of increased promotion of walking and biking for better health. Thus, vulnerable road users have become a focus of safety strategic planning at the state, regional and local levels.

With a multitude of factors, this complex concern for non-motorist safety needs a varied approach utilizing outreach, enforcement, road design and technology. The Look Alive campaign with Signal Woman (lookalivemd.org) was created for the Baltimore region and aims to educate pedestrians, bicyclists and vehicle drivers/operators on how to safely share the road. That program includes visual media, social media and in-person events held in areas of high risk for non-motorists.

Along with Look Alive, there is a law enforcement training seminar focused on enforcing safe roadway crossing. The Maryland Highway Safety Office provides funding for enforcement of non-motorist safety laws, with a focus on drivers not stopping for crosswalk users.

The MDOT SHA developed a Context-Driven Guide and Toolkit centered on establishing safe and effective multimodal transportation systems. These resources work with the state's Pedestrian Safety Action Plan, which aims to work with communities to improve pedestrian safety. Those materials are in use at the state, regional and local levels with roadway planners and engineers to bring a focus to vulnerable road users moving forward.
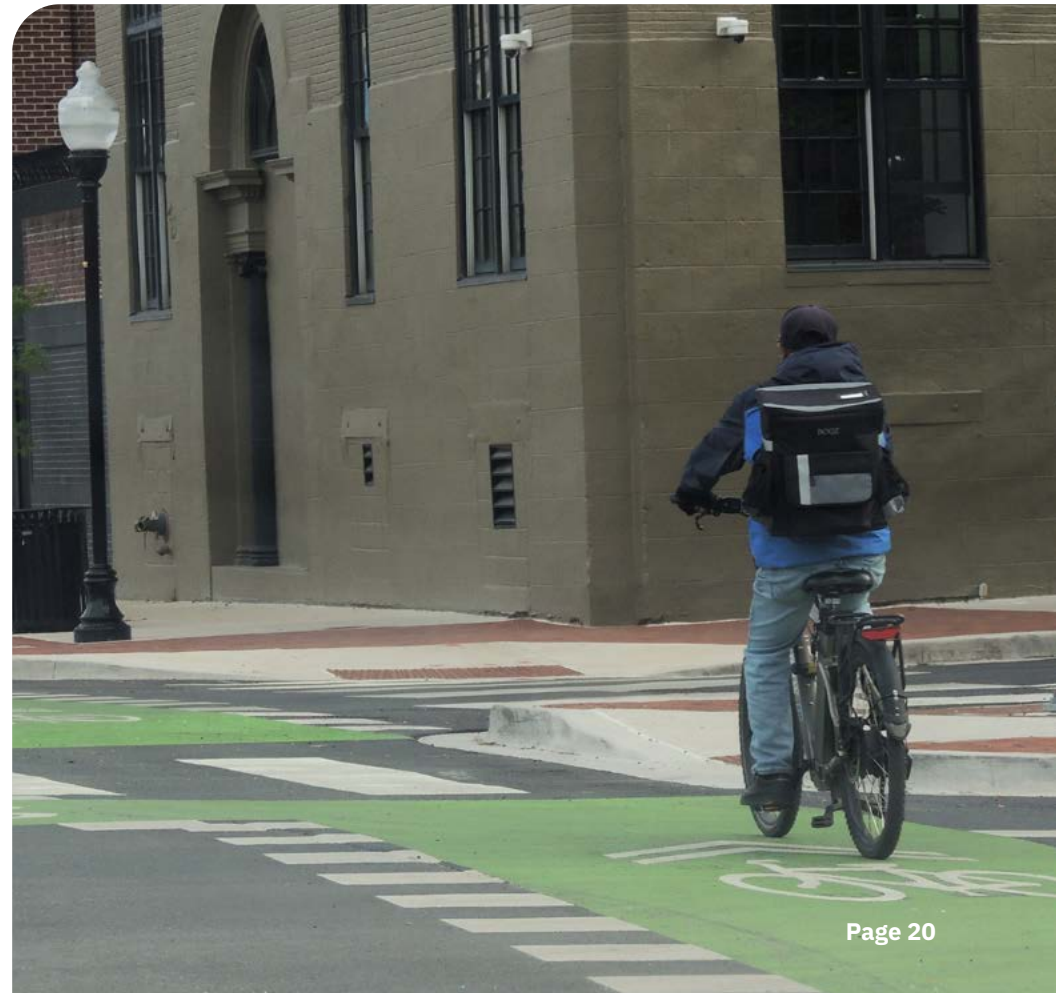
Innovation in vehicle design and road signal technology can also improve non-motorist safety. As vehicle manufacturers continue to implement advanced driver assistance systems (ADAS), such as Automatic Emergency Braking with Pedestrian Detection or stand-alone pedestrian detection and bicycle detection modules, drivers will increasingly be made aware of the presence of non-motorists. In traffic signal design, rectangular rapid-flashing beacons (RRFB) and pedestrian hybrid beacons (PHB), also known as high-intensity activated crosswalk (HAWK) signals, are becoming more common. Non-motorists can activate the RRFB, which then flashes a signal to attract drivers' attention from the

roadside sign. The PHB functions similarly, but the flashing signal bridges the roadway like a traffic light.

Strategic Highway Safety Plans and the Safe System Approach in Local Safety Planning

A marquee safety planning concept is a Strategic Highway Safety Plan (SHSP). The State is currently implementing its fifth SHSP, which was adopted in December 2020 and covers 2021 through 2025. Several years ago, MDOT suggested that each of Maryland's twenty-four jurisdictions develop local strategic plans to complement the State plan. This is important as a notable portion of serious crashes occur on roads that are maintained by local departments of public works or transportation and are under the authority of local police departments or sheriff's offices. In 2020, 40 percent of all crashes, 37 percent of injury crashes, and 28 percent of fatal crashes occurred on county and municipal-maintained roadways (MHSO, 2021). The implementation of local SHSPs ensures that the entire roadway network and population are considered for safety countermeasures. All jurisdictions in the region have an SHSP, with six being implemented.

The Safe System Approach (SSA) is a systemic approach focused on reducing roadway fatalities and serious injuries to zero. Under the SSA, road safety is a shared responsibility among everyone, including those that design, build, operate and use the road system. We are beginning to incorporate the SSA into our work.

Through consultant work, we have undertaken an SSA project to implement and correlate SSA principles and elements into the existing local SHSP frameworks. Those local safety teams are the ideal partners for the SSA because one of its principles is shared responsibility. The process must include planners, behavioral safety and many other experts in transportation fields. That project will deliver best practices, case studies and guidelines for local agency use of the SSA by the end of fiscal year 2023. The SSA is heavily utilized at the national level in the 2021 IIJA and the National Roadway Safety Strategy. Applying the SSA to local SHSPs will enhance each jurisdiction's ability to secure funding and improve safety strategically.

Highway Safety and *Resilience 2050*

Resilience 2050 demonstrates the high priority placed on safety through regional goals and strategies focused on improving system safety (see Chapter 4) and through the project scoring methodology. The technical project scoring methodology allocates 10 out of 50, or 20 percent, of the technical scoring points to projects addressing key safety focus areas including non-motorist safety, speeding and impaired or distracted driving. Points are also allocated to projects anticipated to improve safety for low-income and minority populations. The technical scoring methodology places additional emphasis on non-motorists through five points allocated to projects improving Complete Streets features.

Freight Movement Factors and Trends

The Baltimore region is home to 2.8 million people and is Maryland's leading goods movement center. Each year, more than 307 million tons of freight valued at nearly $1 trillion move over Baltimore's highway, rail, port and airport facilities, serving domestic and international demand for a wide range of goods. The Baltimore region is home to the nation's sixth largest port and two Class I and III regional railroads, as well as the Baltimore/Washington International Thurgood Marshall Airport (BWI). Situated at the midpoint on the eastern seaboard, the Baltimore region also has an extensive roadway network. Maintaining and improving our existing transportation network will improve freight movement and economic growth for our region.

Port of Baltimore

In 2019, the Port of Baltimore handled a record 43.6 million tons of cargo, including 37.4 million tons of international cargo. The Port of Baltimore ranks 11th among major U.S. ports for tons of cargo handled and 9th nationally for total cargo value.

The MDOT Maryland Port Administration periodically updates the economic impacts of the Port of Baltimore on the State of Maryland. Statistics from 2017, the most recent year of data availability, on the economic impacts for cargo and cruise activity are detailed below.

Port activity generates approximately 37,300 jobs in Maryland:

- 15,330 are direct jobs generated by cargo and vessel activities at the Port.

- 16,780 are induced jobs, or jobs supported by the local purchases of goods and services by direct employees. These jobs would be lost in the short term if the direct jobs were lost.

- 5,190 are indirect jobs, or jobs supported by the business purchases of the employers who create the direct jobs. These jobs, too, would be lost in the short term if the direct jobs were lost.

Approximately 101,880 other jobs in Maryland are directly related to activities at the Port. Related jobs are those jobs with Maryland companies that choose to import and export their cargo through the Port of Baltimore, but have the option of shipping their products or supplies through other ports.

The Port of Baltimore is also a major source of personal, business and tax revenue in Maryland. In 2017, the Port was responsible for $3.3 billion in personal income and generated $2.6 billion in business revenues. Port activities also generated $395 million in state, county and municipal tax revenues. The Port's average annual salary for direct job holders is 9.5 percent higher than the average annual wage for Maryland, as reported by the U.S. Bureau of Labor Statistics.

Rail Freight in Maryland

Maryland has a rich history of railroads, including North America's first railroad. Baltimore merchants chartered the Baltimore & Ohio Railroad (B&O) in 1827. The B&O Railroad expanded south to Washington, DC and westward to help capture growing trade within the interior of the United States.

Maryland's freight and passenger railroads carry millions of passengers and millions of tons of cargo each year. Railroads are designated as Class I, II or III according to their annual revenue. There are seven Class I railroads in the U.S., but only NS and CSX operate in Maryland. Freight rail accounts for just under 800 miles of track in the state, as shown in Table 2. Table 2 also includes details on passenger rail in Maryland, including Amtrak, MARC and tourist railroads. Freight railroads transport eleven percent of the tonnage and four percent of total value that passes

Table 2 - Railroads Operating in Maryland

Railroad	Miles Leased	Miles Owned/ Operated	Total Miles Operated (Trackage Right Excluded)
Class I Railroads	5	514	519
Class II Railroads	0	0	0
Class III Railroads	115	132	247
Amtrak	0	97	93
MARC	0	3	3
Tourist Railroads	7	17	24
Total Mileage	127	763	886

to, from and within Maryland. Maryland's freight railroads employ over 2,500 people, which includes direct, indirect and induced jobs, according to the American Association of Railroads (AAR). In addition, nearly 2,700 Marylanders are employed by MARC and Amtrak.

Both passenger and freight rail benefit the region's transportation system and environment. More people and goods moved by rail means less people and goods on already congested highways and interstates. Rail services also help to reduce wear and tear on roadways and provide a safe and affordable transportation option. The AAR estimates that rail is four times more fuel efficient than trucks and produces 75 percent less greenhouse gases on a per ton-mile basis.

Howard Street Tunnel

Maryland has long been considered a freight bottleneck because of the inability to provide double stack trains through the Howard Street Tunnel. By stacking two freight containers on top of each other, double stacking essentially allows for double the efficiency and doubles the amount of freight moved. CSX and NS, along with public sector stakeholders, are making significant investments to provide double stack clearance along the National Gateway and Crescent Corridors including the $466 million Howard Street Tunnel project.

The Howard Street Tunnel project is being funded with a combination of federal INFRA discretionary grant funds, state funds from Maryland and Pennsylvania, and private

funds from CSX. When complete, the project will eliminate all double stack obstructions between Baltimore and Philadelphia and provide economic benefits, economic growth and additional jobs for the Baltimore region. The project will also reduce truck trips, yielding other benefits including reduced congestion on Maryland's highway system, increased roadway safety, decreased fuel consumption and improved air quality. Construction began in early 2022 in Pennsylvania, with completion expected in mid-2025.

Air Freight in Maryland

The Baltimore Washington International (BWI) Thurgood Marshall Airport employs over 9,700 people, with thousands more employees related to airport operations. Air cargo at BWI has averaged annual increases of more than 19 percent over the last five years and has more than doubled since 2015. BWI also recently became one of Amazon's top five busiest air cargo facilities in the nation (out of 35). Air cargo at BWI accounts for 57 percent of regional air cargo and exceeds the amount of cargo at Dulles International and Reagan National airports combined.

The pandemic had a significant impact on air travel. Business and leisure travel were greatly reduced due to travel restrictions and public health concerns. This led to an unprecedented demand for e-commerce. Data shows that freight (by weight) increased by 17.4 percent from February 2019 to February 2021. BWI set a new annual record for cargo

Freight and the Infrastructure Investment and Jobs Act (IIJA)

In November of 2021, President Joe Biden signed the Infrastructure Investment and Jobs Act, or IIJA. The IIJA continues to build upon past legislation, adding roughly $244 billion in new investments affecting freight transportation, including $110 billion for roads and bridges, $66 billion for railroads and $25 billion for airports.

IIJA established the Office of Multimodal Freight Infrastructure and Policy, which will administer multimodal freight grant programs, facilitate information sharing between private and public sectors, conduct research on freight mobility, provide technical assistance to cities and states and manage planning activities such as the National Freight Strategic Plan and National Multimodal Freight Network.

The IIJA also provides additional guidance on freight planning including key updates to the National Freight Plan for assessing the environmental impacts of freight movement on air quality and wildlife habitat loss, the unique impacts of the national freight system on rural, underserved, and disadvantaged communities, and considering the impacts of e-commerce on the national multimodal freight system. The IIJA also recommends that states consider the impacts of e-commerce and the impacts of extreme or severe weather on freight infrastructure when developing state freight plans.

operations in 2021, with more than 618.8 million pounds of cargo transported. In 2021, BWI's cargo operations accounted for more than 55 percent of the total air cargo flown through the region's three major commercial airports. July 2021 marked a record month for cargo shipments at BWI, with nearly 56.3 million pounds of cargo. The airport's 200,000 square-foot Midfield Cargo Building H, which opened in 2019, has helped accommodate cargo increases.

Bottlenecks

Over the last few decades, the U.S. has seen steady growth in the demand for freight transportation. Unfortunately, freight transportation capacity, especially highway capacity, has failed to keep pace with the growing demands. The combination of growing demand and limited capacity results in congestion, less reliable trip times and difficulties meeting delivery times.

Bottlenecks on roadways that serve a high volume of trucks can be considered "freight bottlenecks." These roadways tend to serve international gateways, major domestic freight hubs and major urban areas such as Baltimore City. The majority of bottlenecks (60 percent) can be attributed to non-recurring events such as weather, work zones, crashes, breakdowns and poorly timed traffic control.

Recurring bottlenecks have the greatest impact on freight movement. There are many causes for recurring truck bottlenecks. Steep grades, lane drops, merges and signalized intersections are just a few. Most freight

bottlenecks occur on Interstates or arterial roadways, but bottlenecks can also happen in localized places such as entrances to ports and airports.

Bottlenecks cause significant delays and costs in the Baltimore region. In 2019, there were 3.32 million truck person-hours of delay with an estimated cost of over $161 million. Table 3 summarizes hours of delay and its associated costs for jurisdictions in the Baltimore region.

What We Are Doing to Address Issues

We work with stakeholders to ensure that our transportation system supports the safe and efficient movement of

Table 3 - Truck Person-Hours of Delay and Costs in Baltimore Region Jurisdictions (2019)

Location	Hours of Delay	Cost of Delay
Anne Arundel County	653,512	$31,987,810
Baltimore City	940,853	$44,819,136
Baltimore County	1,018,310	$49,574,336
Carroll County	116,448	$5,822,750
Harford County	213,428	$10,553,599
Howard County	335,256	$16,344,500
Queen Anne's County	40,065	$1,930,658
Total	3,317,872	$161,032,789

Source: MDOT SHA Maryland Roadway Performance Tool

freight upon which our economy, jobs and consumers rely. Our Freight Movement Task Force (FMTF) includes representatives from MDOT SHA, MDOT Maryland Port Administration, MDOT Maryland Transportation Authority, Maryland Motor Truck Association, Federal Highway Administration, Federal Motor Carrier Safety Administration, NS, CSX, private sector consultants and others. The mission of the FMTF is to provide the freight/goods movement community a voice in the regional transportation planning process and to serve as a forum for Baltimore region freight stakeholders to share information.

MPOs may designate Critical Urban Freight Corridors (CUFCs) in consultation with the state in urbanized areas with populations of 500,000 or more. A public road designated as a CUFC must meet one or more of the following four elements:

- Connects an intermodal facility to the highway freight system, the Interstate System or an intermodal freight facility
- Is located within a corridor of a route on the highway freight system and provides an alternative highway option important to goods movement
- Serves a major freight generator, logistic center or manufacturing and warehouse industrial land
- Is important to the movement of freight within the region, as determined by the MPO or state

Table 4 lists the current CUFCs for the region. We anticipate approving an updated list of CUFCs in fall 2023 as the maximum allowable CUFC mileage has increased from 25 to 50 miles.

We are also responsible for approving the short-term TIP for the region. The TIP has included several capital projects that include federal freight program funds from the National Highway Freight Program (NHFP) including:

- I-695: US 40 to MD 144 – NHFP funds in FY 2018
- I-83 Bridge Replacement over Padonia Road – NHFP funds in FY 2018

- I-695: I-70 to MD 43 – NHFP funds in FY 2022 and 2023
- I-695: Reconstruction of Interchange at I-70 – NHFP funds programmed for FY 2025-2026
- I-695: Bridge Replacements at Benson Avenue and US 1 – NHFP funds in FY 2018 (Complete)
- I-695: Bridge Replacement on Crosby Road – NHFP funds in FY 2018 (Complete)

In addition to freight movement, truck parking is increasingly a concern for drivers and motor carriers. In an effort to better facilitate freight travel and truck parking across Maryland, MDOT SHA has engaged in multiple endeavors including the 2020

Table 4 - Critical Urban Freight Corridors in the Baltimore Region

Jurisdiction	Road Name	Starting Point	Ending Point	Miles	Cumulative Total
Baltimore City	Broening Highway	Boston Street	Belclare Road	1.9	-
	E. Lombard Street	Haven Street	Kane Street	1.0	2.9
	Boston Street	Fleet Street	I-895	1.9	4.8
	O'Donnell Street	S. Conkling Street	Dundalk Avenue	1.7	6.5
	MLK Jr. Boulevard	N. Howard Street	I-395	1.7	8.2
Anne Arundel County	New Ridge Road	MD 100	Stoney Run Road	1.8	10.0
	MD 100	MD 295	I-97	5.6	15.6
Baltimore County	Rolling Mill Road	Erdman Avenue	Eastern Boulevard	1.3	16.9
	US 40 (Pulaski Highway)	Philadelphia Road	MD 695	2.7	19.6
	Broening Highway	Belclare Road	I-695	2.0	21.6
Carroll County	MD 97	MD 140	Bachmans Valley Road	1.8	23.4
Harford County	MD 543 Interchange	I-95	I-95	0.0	23.4
Howard County	MD 175	US 1 (Washington Boulevard)	MD 108	1.0	24.4
	US 1	Montevideo Road	Assateague Drive	0.6	25.0

Statewide Truck Parking Study. This study seeks to identify truck parking needs and the development of an emergency truck parking program allowing trucks to use park-and-ride facilities during emergencies such as storms or major roadway disruptions. MDOT SHA is currently assessing truck parking data and is identifying state-owned property and potential partnerships with private property owners that could support truck parking expansion. This includes non-traditional parking locations such as big lot properties that do not mind truckers on site.

Trends in Freight Delivery – Questions to consider

Planners need to consider questions related to how goods might be delivered in the future. For example:

- What role might autonomous trucks play in freight delivery over the next five, ten or twenty years? Are there other factors particular to the trucking industry that transportation planners, economists and regional decision makers should consider?

- How will consumers' changing habits continue to shape how goods are delivered? A February 2019 analysis by the American Transportation Research Institute noted that the annual growth of e-commerce has ranged between 13 and 16 percent over the last five years, compared to the 1-5 percent annual growth in traditional retail sales. How will this trend affect the trucking industry?

- How will the changing habits of consumers affect land use decisions about whether and where to place stores and distribution centers? How will locations and operating hours of stores and distribution centers affect decisions on how customers, workers and freight operators will access such facilities?

- Will expectations about the amount of time needed to deliver goods continue to evolve—from next-day to same-day to, potentially, same-hour?

- Could drone deliveries eventually become a viable alternative to traditional shipping, and how might this affect the trucking industry?

These are just some of the questions that planners will need to consider in the coming years. We don't have the answers to these questions yet. Evolving preferences and business models demand at least an awareness of the potential for change. There could be great opportunities to operate more efficiently and rethink the "business as usual" approach. We will continue to stay informed about trends in freight delivery so that the region will be prepared to accommodate change.

Emerging Technologies

This section focuses on a few of the emerging technologies that have significant potential to transform the transportation industry during the planning period for *Resilience 2050*. These include Mobility on Demand, micromobility, electric cars and Connected and Automated Vehicles. All of these technologies are already operating in the region in some form. We will continue to research the potential impacts of these technologies, encouraging policies and programs that support implementation where appropriate while also recognizing the significant uncertainties surrounding implementation. In preparation for *Resilience 2050*, we released a more detailed Emerging Technologies white paper.

Mobility on Demand (MOD)

MOD is an innovative transportation concept already operating in the region. These services allow consumers to access mobility, goods and services on demand by dispatching or using ride-sourcing from a variety of providers. Services currently operating in the region include transportation network companies such as Uber and Lyft, e-scooters and e-bike sharing services, shuttles, public transportation, courier network services and Personal Delivery Devices such as Kiwibot. Connected and automated vehicle services will very likely be used sometime in the *Resilience 2050* planning period.

Micromobility

An emerging technology that has become more important to the region of late is micromobility. Micromobility is the use of small, fully or partially human-powered vehicles such as bikes, e-bikes and e-scooters for typically short distance travel purposes. The Federal Highway Administration used the Society of Automotive Engineers International's Taxonomy and Classification of Powered Micromobility Vehicles to broadly define micromobility as "any small, low-speed, human- or electric-powered transportation device, including bicycles, scooters, electric-assist bicycles, e-scooters and other small, lightweight, wheeled conveyances."

Private companies, taking advantage of recent innovations in battery and vehicle design, have increased their availability to the public via shared-use fleets. These companies offer a service that has proved a popular transportation option as an alternative mode for short trips. These vehicles are rented through a mobile app or kiosk, and are "dockless", meaning they are picked up and dropped off in the public right-of-way. State and local laws govern operations of these services. State and local agencies monitor and respond to emerging technologies in order to protect the public interest and adapt to and take advantage of how these technologies are reshaping the mobility choices of our residents and businesses.

Baltimore City has the largest set of micromobility services in the region, has a growing record of accomplishment since the launch of its dockless vehicle program in 2019 and offers an array of best practices for others. Its annual permit program has seen stiff competition and saw an impressive pre-COVID ridership high of over 76,000 weekly trips in September of 2019.

The Future of Micromobility in the Region

Some services are (or very soon will be) available in many places in the region (such as Annapolis, Columbia, Gateway and Ellicott City), and new services are expected to continue to grow. Public safety is a major concern. While the majority of e-scooter trips end without incident, much work remains to improve comfort and safety for e-scooter riders with different levels of experience, training and travel needs. Future service
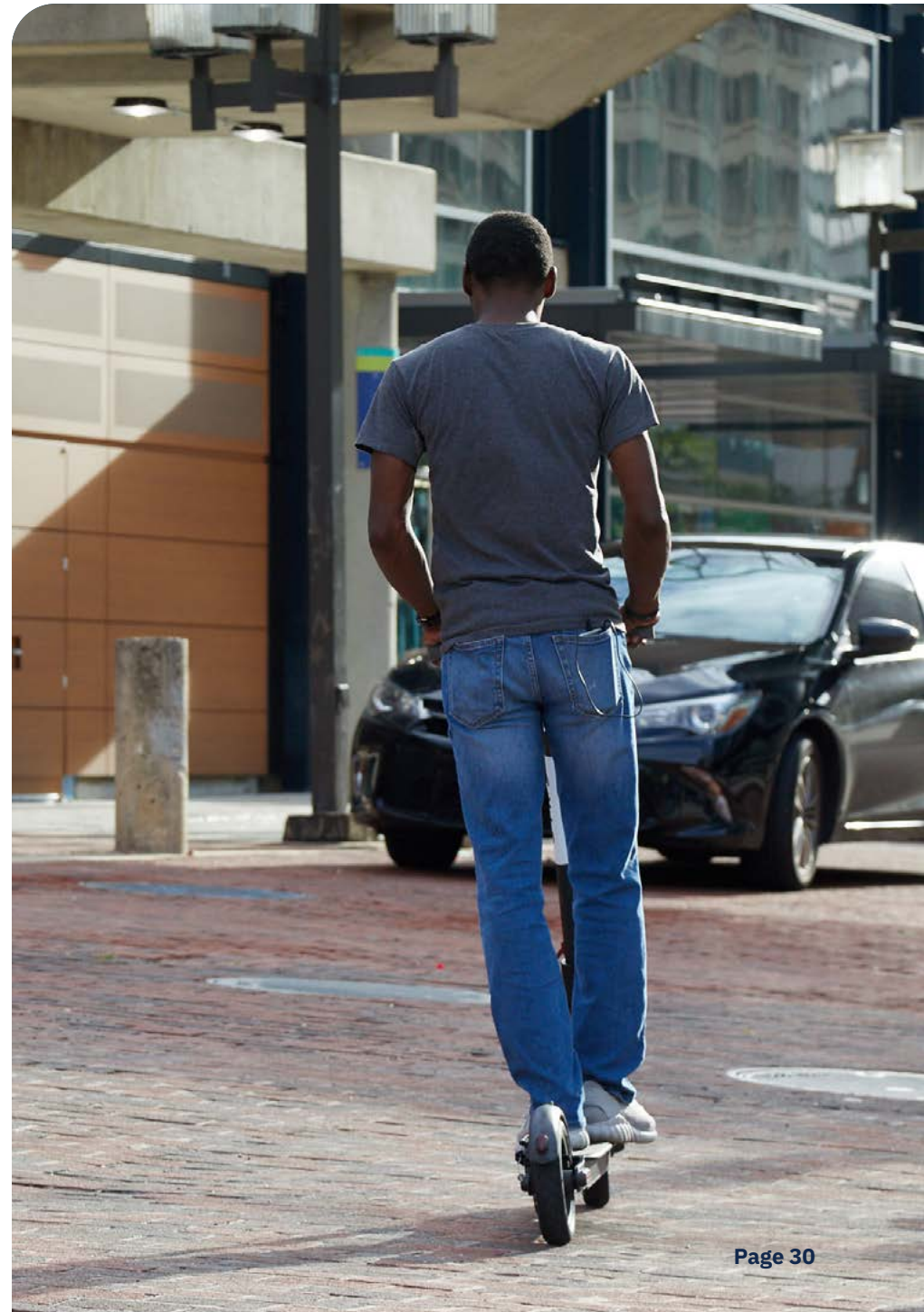
should address issues such as speed management, user education, improved roadway design, community engagement to help mitigate risks for vulnerable road users and the need for a connected network of facilities dedicated to serving micromobility.

Vehicle Technologies: Electric Vehicles, Advanced Driver Assistance Systems & Connected and Automated Vehicles (CAV)

In the Baltimore region, the majority of the traveling public goes to work, school, play and other activities by automobile. However, while vehicles are expected to continue to remain the dominant means of getting around, the vehicle fleet is changing in ways that can address some of their issues of safety and impacts to the environment. In our region, we are seeing an ongoing rise in the number of electric and other alternatively fueled vehicles being registered for use on our roadways.

Electric Vehicles

As of January 31, 2023, there are 64,395 electric vehicles registered in Maryland. President Biden signed an executive order in August of 2021 that called on the federal government to do all it can to support electric vehicles by setting a goal that "…50 percent of all new passenger cars and light trucks sold in 2030 be zero-emission vehicles." Increasing electrification of our vehicle fleet would provide multiple benefits, from reducing the carbon footprint of the transportation sector, to saving money and supporting the

economy. A California rule requiring 100 percent of new cars, light trucks and SUVs sold in that state to be zero-emission vehicles by 2035 is expected to significantly motivate manufacturers and the market in ways that may have implications here in Maryland. While electric vehicles are expensive to many, they cost considerably less to drive than those using diesel fuel or gasoline.

Electrifying heavy trucks and buses could also provide significant benefits as these are among the most polluting vehicles on the road. Heavy-duty trucks are responsible for nearly a quarter of the greenhouse gas emissions from the nation's transportation sector, itself the biggest contributor of those emissions in the economy. Logistics companies are realizing that shifting away from internal combustion engines could provide large economic benefits to high-use commercial fleets, especially as purchase prices drop and the market changes because of policies like California's. In our region, Amazon has begun its efforts to increase shipments made by electric or non-motorized vehicle. Additionally, Walmart intends to complete converting its fleet to electric, hydrogen or renewable diesel vehicles by 2040. These efforts and others have the potential to transform at least 30 percent of new trucks to zero-emission vehicles by 2030 — and as much as 100 percent of the additions to urban fleets of transit buses, trash trucks, postal vehicles, cargo vans and heavy-duty trucks. This would have significant positive impacts on the region's air and water resources.

Advanced Driver Assistance Systems (ADAS)

We are also seeing advanced vehicle technologies appear in our vehicles. ADAS technologies currently include Automatic Emergency Braking, Lane Keeping Assistance, Blind Spot Warning and other advanced safety technologies. ADAS are passive and active safety systems designed to remove human error when operating vehicles of many types. ADAS systems use a combination of sensor technologies to perceive the world around the vehicle, and then either provide information to the driver or take action when necessary. ADAS technologies enable cars to take actions similar to a driver – sensing weather conditions, detecting objects on the road – and make decisions in real time to improve safety. ADAS features can include automatic emergency braking, driver monitoring, forward collision warning and adaptive cruise control.

Driver assistance technologies are already helping to save lives and prevent injuries. Many vehicles on the road today have the crash avoidance features mentioned above. In addition, Maryland now has more than forty connected vehicle roadside units in Montgomery and Prince George's counties that broadcast key roadway information to drivers. Data is exchanged with these in-vehicle technologies, and data security is a concern. In response, MDOT launched a statewide system allowing any agency to register their roadside units. This is intended to increase trust and cybersecurity of connected vehicle data exchanges.

Drivers and operators must understand the limitations of these technologies. While an ADAS can often steer, brake and accelerate vehicles on its own, the driver must be prepared to take control quickly when the technology malfunctions or cannot handle a particular situation. Drivers may become complacent or unaware of the limits of ADAS features, resulting in an emergency when they are not alert to the need to take over driving quickly. This is reflected in the unfortunate and growing record of crash data, demonstrating drivers don't yet have a firm understanding of the limitations of current driver assist technologies. Driver education of the capabilities and limitations of these technologies is critical. The need for driver education is expected to continue throughout the planning period as new technologies emerge.

Connected Vehicles (CV)

CV technologies use onboard communication devices and systems to address safety, efficiency and mobility on our roadways. Connected vehicles use technology to either communicate with each other, connect with traffic signals, signs and other road items, or obtain data from a cloud. The connected vehicle concept uses technology to "sense" what other travelers (vehicles, bicyclists, pedestrians, wheelchairs, motorcycles, buses, trucks and others) are doing and identify potential hazards. They are leveraging technologies and solutions to improve traffic flow, an important consideration as travel patterns and congestion return to pre-pandemic levels. Connecting to databases and platforms and allowing vehicles to communicate in real time helps vehicles adjust speed and route and avoid conflicts.

CV (and CAV – see below) technologies are not only transforming vehicles, they are subtly forcing a reimagining of the design of transportation infrastructure. Fully realizing the benefits of CV requires designing connectivity into roads, sensors and cameras, signage and traffic lights. These shifts are anticipated to be a significant challenge throughout the planning period.

Additionally, each CV contributes and benefits from the real time exchange of information with other vehicles and roadside infrastructure, resulting in huge amounts of data. This data is a valuable product and raises complex questions surrounding data management and ownership.

These issues represent possible implementation barriers throughout the planning period.

Automated Vehicles (AV)

AV technology is evolving to deliver greater safety benefits than earlier technologies. However, with the exception of Personal Delivery Devices (see below), fully automated vehicle technology is not expected to appear until later in the planning period. Automated driving systems, or automated vehicles, are operating in other parts of the country. The U.S. Department of Transportation (DOT) defines automated vehicles as those in which at least some aspect of a safety-critical control function (such as steering, throttle or braking) occurs without direct driver input. Automated vehicles may be autonomous (use only vehicle sensors) or may be connected (see discussion in above section) and communicate with other vehicles, or may be both connected and autonomous. Connectivity is an important input to realizing the full potential and implementation of automated vehicles.

AVs use sensors and other technologies to understand the environment to assist drivers, and eventually perform driving tasks in place of a human driver. AVs can operate independently from other vehicles and infrastructure using onboard sensors. There are several "levels" of automation:

- Level 0: No Automation;
- Level 1: Driver Assistance;

- Level 2: Partial Automation;
- Level 2+: Advanced Partial Automation;
- Level 3: Conditional Automation;
- Level 4: High Automation; and,
- Level 5: Full Automation.

Vehicles with an automated driving system (level 5), which some refer to as "self-driving" cars, are a future technology and are not available for purchase and use today.

Connected and Automated Vehicles (CAV)

Connected and Automated Vehicles (CAVs) combine the two technologies discussed above. They use special short-range radios to wirelessly communicate with each other and with vehicles around them, traffic infrastructure and other travelers and automate some or all of the driving functions. The vehicle and roadside infrastructure – like traffic signals, crosswalk signs and blind roadway curves – communicate to make traveling safer.

CAV technology has the potential to save lives, prevent injuries and reduce crashes. CAV could also increase mobility to meet the needs of those with disabilities, the elderly or those otherwise unable to drive. CAV technology may also help traffic move more efficiently by providing accurate data to drivers and traffic managers. As traffic moves more efficiently, there will be a reduction in vehicle emissions and improved air quality.

While the expectation is that CAVs will lead to all of these benefits, there will likely be challenges as well. Some can be identified in advance, such as the need to ensure these technologies are deployed equitably, the potential for cyberattacks on CAVs and changes to land use to accommodate CAVS. Of course, unanticipated challenges will also arise. The public sector must work with the private sector to identify and address any challenges as early as possible to maintain and even increase safety, mobility and equity.

Transit and Transit Signal Priority

Fully realizing the promise of connected vehicles requires transit agencies to revisit transit signal priority (TSP) systems in the hopes of restoring route reliability and on-time performance. TSP is a general term for operational improvements that use technology to reduce time at traffic signals for transit vehicles by holding green lights longer or shortening red lights. TSP may be implemented at individual intersections or across corridors or entire street systems.

Connected and Automated Vehicle Technology has the potential to save lives, prevent injuries and reduce crashes.

TSP systems haven't evolved much and rely on transmitters on buses that send messages to receivers installed on traffic signals. They are also quite expensive and require annual maintenance to guarantee operation.

Recent advances in communication technologies and access create opportunities for transit agencies to reduce the cost of TSP solutions while maximizing their current investments. Transit agencies have begun placing tracking devices on each of their vehicles to understand in near real-time where vehicles are located. This technology is beginning to bridge the gap between transit vehicles and traffic signals to facilitate transit priority in a more reliable, sustainable, cost-effective and intelligent way.

AV Shuttles

Self-driving shuttles are in use around the world. Autonomous shuttles are vehicles that move autonomously at low speeds (less than 50 miles per hour) on pre-charted routes under remote surveillance and environment restrictions for operations. Autonomous vehicles under this category are electric, used to ferry people or deliver goods and may be manned or unmanned. These are often small transit vehicles that can transport 10 to 15 passengers in a relatively small area defined by pre-charted maps and well-defined routes. They also require geography-specific customizations like identifying common objects and understanding the local traffic laws and regulations. The driving scenario for the vehicle

is generally simple, with well-defined emergency protocols. Shuttles typically have a remote operator functioning as a safety fallback. In addition, shuttles generally do not share the road space with faster moving traffic.

Autonomous shuttles have functioned best in closed environments such as campuses (business, industrial or educational), certain city centers and suburban neighborhoods. A self-driving shuttle had operated within National Harbor in Prince George's County, but is no longer operating. A public-private collaboration, the Mid-Atlantic Gigabit Innovation Collaboratory (MAGIC), is now working to enable a self-driving shuttle in Westminster. This work is in the early stages and an estimate for deployment is not yet available.

Truck Platooning, Personal Delivery Devices and Unmanned Aerial Vehicles

Truck Platooning

Technologies that support the movement of freight and goods have already started in the region. Truck platooning is a technology involving truck operators with vehicle-to-vehicle (V2V) communications technology on board. This V2V technology enables truck operators to safely close distances between moving vehicles, allowing two or more vehicles to be electronically synced to one another. The platooning vehicles wirelessly communicate information on braking, speed and oncoming obstacles, allowing the following trucks to have

consistent and predictable driving behavior. The use of these systems drastically reduces the reaction time of the following trucks in a platoon, thereby reducing the likelihood of rear-end or chain-reaction crashes.

Platooning in Maryland is only currently allowed on the state's controlled access highways. As the technology evolves, consideration of platoons with more than two trucks, platoons for other heavy vehicles including buses and military vehicles and platoons with a human driver in the lead vehicle and an automated driver in the following vehicle may be considered. This technology is expected to improve safety, the environment, commerce and infrastructure for Maryland's roadways and freight services.

Personal Delivery Devices (PDD)

PDDs have also begun delivery services in the region. PDDs have emerged as an innovative technology promising to improve the efficiency of deliveries. A 2021 law set out specific rules for PDDs in Maryland, authorizing PDDs and defining guidelines to operate on any highway, roadway, sidewalk, shoulder, footpath, bicycle trail or crosswalk in the state.

Morgan State University has begun the use of PDDs on campus. A private company has deployed a fleet of "KiwiBots" to provide the university's food-service provider, Sodexo, delivery services. MSU students can use their mobile device to place orders and meet the small, semi-autonomous robots on campus between classes or whenever is most

convenient. Kiwibot's PDDs are the first permitted automated vehicle on the streets in Maryland and the company hopes to expand. This and other similar PDD services will require reviews of the route and safety considerations from multi-disciplinary experts including staff from state and local public safety and public works agencies, as well as providing notice to the general public.

Unmanned Aerial Vehicles (UAV)

UAV systems, sometimes called drones, are being explored as a means to transport lightweight packages, medical supplies, food and other goods. Currently, companies in the

image courtesy of FedEX

U.S. and worldwide are actively vying to define their markets and begin operations. This newer mode of transportation has the potential to change last-mile delivery economics for smaller and lighter packages by replacing deliveries currently made by traditional car, van or truck delivery services.

Potential benefits of UAV delivery include reductions in traffic congestion, environmental pollution, delivery times and transportation costs. There are, however, significant challenges to broader overall usage and acceptance of drone delivery systems. Their use in the region for such purposes is expected to be limited throughout the planning period.

While broader usage of UAVs or drones for delivery remains a challenge, MDOT currently uses drones in a variety of ways. Current uses of drones by MDOT include assessing damage to the transportation network, conducting stormwater facility inspections, tracking construction projects, assessing utilization of Park-and-Rides and viewing geohazards such as sinkholes.

Advanced Air Mobility

Advances in technologies in air travel and better connections with surface modes have necessitated their consideration in metropolitan LRTPs. Understanding the role of Advanced Air Mobility (AAM) and the evolving relationship between new AAM systems and the region's surface-based transportation systems, such as the integration of electric vertical takeoff

and landing (eVTOL) air taxis, will require closer coordination among federal, state, regional and local governments and the private sector. AAM is expected to play a critical role in the future and the safe integration of AAM infrastructure and facilities into our regional multimodal transportation system will be vital.

Currently, proposed AAM aircraft incorporate new features like electric propulsion and vertical flight capabilities that Federal Aviation Administration (FAA) regulations do not yet cover. As research progresses, and particularly when the technologies advance automated and autonomous services, public acceptance issues are expected to increase and become more fraught.

The supporting infrastructure (such as electricity) and standards for developing this infrastructure are not fully formed and require more attention, even as long-range transportation and land use planning must take them into account. For example, selecting safe and viable vertiport locations will be critical to their successful implementation. Further, the development of new AAM infrastructure will require significant investment, and at present, funding sources are not clear. The region must anticipate that a combination of federal, state and local funding, as well as private investment, will be necessary to support the development of AAM infrastructure.

The FAA is encouraging state and local governments to actively plan for AAM infrastructure to ensure transportation equity, market choice and accommodation of demand for their communities. DOT recently created a working group to coordinate and develop standards and requirements for this nascent space. As with other emerging transportation technologies, the region must closely coordinate with its partners to ensure safe and optimal planning and implementation of AAM to maximize its benefits and avoid or mitigate its challenges.

Emerging Technologies and *Resilience 2050*

Technologies are constantly changing and there remains a significant amount of uncertainty surrounding the impact of emerging technologies. As use of these emerging technologies becomes more widespread, we will continue to monitor potential risks and impacts and identify actions to take. Understanding the potential and consequences of technologies is important to help to ensure the region harnesses the positive effects of technology and avoids or minimizes potential negative effects.

We must be prepared to face rapid advances and implementation issues while continuing to make investment decisions and develop programs and projects that support a safe, efficient, accessible, equitable and environmentally responsible transportation system for all users.

Our specific actions will include:

- Tracking technology development and deployment within the region, nationally and internationally to understand and plan to take full advantage of the benefits and minimize disadvantages from new and emerging technologies

- Investigating how to use newly available data to enhance transportation planning

- Working with stakeholders, especially elected officials and the public, to manage expectations and perceptions, minimize future problems and leverage opportunities

- Building technical, institutional and policy capacity, and including new partners as necessary

- Working to monitor deployment throughout the region to ensure equitable distribution of the benefits technology can offer

Travel and Tourism

Federal law requires that metropolitan regions consider a series of factors when developing their transportation programs and plans. These factors address issues such as supporting the economic vitality of the metropolitan area, increasing the safety of the transportation system for motorized and non-motorized users, and protecting and enhancing the environment, among others. "Enhance travel and tourism" was added as a factor starting with the Fixing America's Surface Transportation (FAST) Act and is maintained in the IIJA.

The conference report prepared during the development of the FAST Act notes that:

- One out of every nine jobs in the U.S depends on travel and tourism, and the industry supports 15 million jobs in the U.S.

- The travel and tourism industry employs individuals in all 50 states, the District of Columbia, and all of the territories of the U.S.

- International travel to the U.S. is the single largest export industry in the country, generating a trade surplus balance of approximately $74 billion.

- Travel and tourism provide significant economic benefits to the U.S. by generating nearly $2.1 trillion in annual economic output.

- The U.S. intermodal transportation network facilitates the large-scale movement of business and leisure travelers, and is the most important asset of the travel industry.

Understanding the Context: Enhancing Travel and Tourism

Our advisory Technical Committee has heard presentations from two organizations charged with promoting tourism in the area: Visit Baltimore and the Maryland State Office of Tourism Development.

In its 2022 Annual Report, the Maryland Tourism Development Board reports that Maryland's tourism economy began to recover from COVID-19 related declines in late 2020. The recovery continued in 2021, with visitation increasing by 42 percent to reach 35.2 million trips. This is 84 percent of pre-

pandemic levels. Visitor spending grew by a similar 41 percent to reach $16.4 billion. Growth from 2020 to 2021 spanned many sectors, with transportation spending by travelers increasing by 53 percent, recreational spending increasing by 44 percent, lodging spending surging by 41 percent and food and beverages spending increasing by 34 percent.

Tourism also supports Maryland employment along with its tax base. Tourism-supported employment decreased by 30 percent from 2019 to 2020 due to the COVID-19 pandemic. However, it increased by 8.2 percent in 2021 to nearly 113,000 jobs. The number of jobs is still about 37,000 below pre-pandemic levels. Sales and use tax revenue attributable to tourism decreased by 31 percent to $294.1 million in FY 2021. It rebounded by more than 100 percent to $615.8 million in FY 2022.

Visit Baltimore is the official destination marketing organization for Baltimore. It strives to inspire people to visit the Baltimore region, generate economic benefits through the power of collaboration and partnership, provide stakeholders with the necessary tools and information to make their products and services competitive and approaches its work through the lens of Diversity, Equity, and Inclusion (DEI).

Visit Baltimore has highlighted some recent statistics regarding the impact of travel and tourism in Baltimore. Domestic travel to Baltimore increased by 13.3 percent in 2021, resulting in 24.3 million people visiting for overnight and day trips. The economic impact of these visitors brought in $2.7 billion to Baltimore's economy in 2021. Baltimore Convention Center events alone brought in an estimated economic impact of $90 million in 2021.

Enhancing Travel and Tourism – Input from Advisory Committees

Building on input from tourism agencies, the Technical Committee recommended additional language related to travel and tourism to support our regional transportation goals and to address the new planning factor. This language was included in the previous LRTP and is also supported in the goals and strategies for *Resilience 2050*. The goal for promoting prosperity and economic opportunity includes the following strategy related to tourism: "Invest in upgrading transportation assets and facilities that promote tourism and the movement of tourists within and through the region." This could include:

- improving roadway, transit, pedestrian and bicycle access to regional and local tourist attractions

- analyzing peak travel volumes and times in key tourism corridors and

- improving and promoting information systems (such as signage, bus service information and smartphone applications) that visitors can use to reach destinations easily and safely.