

Choices for Stewardship: Recommendations to Meet the Transportation Future

VOLUME I

Submitted Pursuant to
Executive Orders 579 and 580



COMMISSION ON THE FUTURE OF TRANSPORTATION IN
THE COMMONWEALTH

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Volume II: Background Books – Facts, Trends & Issues

Volume II of the Commission’s Report represents ten months of research, learning, and input from a range of academic, industry, and advocacy sources. The Commission cast a wide net for information so as not to limit our thinking on the disruptive forces facing Massachusetts’ transportation network and on the potential approaches that will best enable the Commonwealth to be ready for them. The data-based information that was gathered has been organized into five Background Books that report on the various trends that have significant implications for our transportation network; the collection of these Background Books is presented as Volume II. The Commission believes that this work will be a valuable resource for other states as they consider ways to prepare themselves for the changes that they are sure to face in the future.

The five Background Books that comprise Volume II are [posted on our website](#):

1. Demographics and Land Use
2. Transit, Active Transportation, and Mobility Services
3. Autonomous and Connected Vehicles
4. Climate Change and Resilience
5. Transportation Electrification

Additional Resources

[The Commission hosts a website where](#), in addition to electronic versions of Volumes I and II, interested parties can find information regarding the five Public Listening Sessions, and information about the Commission including Commissioner biographies.

Cover Letter

Governor Baker and Lt. Governor Polito,

We are honored to present to you and to the people of the Commonwealth *Choices for Stewardship: Recommendations to Meet the Transportation Future*, the report of the Commission on the Future of Transportation in the Commonwealth. Executive Order No. 579 established the Commission and charged it with imagining Massachusetts in 2040. This report is the product of ten months of work by the nineteen appointed Commission members, each of whom brought his or her own perspectives and experiences to the Commission from across the Commonwealth, across a range of professions, and across a diversity of viewpoints. Executive Order No. 579 identified several key trends for the Commission to consider, including changing demographics, a more volatile climate, disruptive technological advances, increased electrification, and a higher level of automation. Taken together, these phenomena represent a level of uncertainty about the future of mobility that has not been seen since the widespread adoption of the private automobile. You challenged us to report to you by December 1, 2018 with our recommendations for how the Commonwealth can best prepare its transportation system and its people for this changing world. This report is the culmination of that effort.

Throughout its work, the Commission was supported by staff from the Massachusetts Department of Transportation (MassDOT) and the Executive Office of Energy and Environmental Affairs (EEA), as well as by inspiration and input from transportation stakeholders and thinkers across Massachusetts and from elsewhere in the United States. The Commission held five listening sessions at University of Massachusetts campuses around the Commonwealth to solicit concerns and ideas. Moreover, the Commission also benefited from the expertise and resources of the National Cooperative Highway Research Program (NCHRP) of the Transportation Research Board (TRB), a program unit of the National Academies of Sciences, Engineering, and Medicine, which partially funded a team of consultants to assist the Commission in its research and scenario development. The NCHRP Report 750 Foresight Series on the use of scenario planning in a transportation context, particularly its early work, served as a model for the Commission.

The Commission believes that this report fully reflects the ideas we have heard and discussed, the tradeoffs that have been weighed, the opportunities that are before us, and the potential pitfalls of which Commonwealth leaders should be aware. The Commission was fortunate to hear from local stakeholders throughout its work, which helped us to appreciate both the significance and urgency of the challenges before us. An optimal transportation system provides safe, reliable, and efficient mobility that allows society to go about its business without undue delay. That is not the transportation system that Massachusetts has today, but it is the one that Commonwealth residents, workers, businesses, and communities deserve.

Although geographically small, Massachusetts is a diverse state with stark differences between east and west, especially around issues of mobility and economic prosperity. The Commission has taken its commitment to develop recommendations that have statewide relevance seriously, but has also noted the places where a single unified policy would not accurately reflect or speak to the differences of opportunity and social outcomes within the Commonwealth. Rather than minimizing the importance of needs for places outside of Boston, explicit acknowledgement that different areas of Massachusetts require different approaches will better tackle the Commonwealth's future potential.

The approach of the Commission has been to ground all recommendations in data. One product of the Commission's work is a series of Background Books on key facts, trends, and issues dedicated to capturing our best understanding of the transportation-related trends currently confronting Massachusetts. Although broken into the five topics of primary focus for the

Commission, one of the messages of the Background Books is the interconnectedness of many of the major forces influencing the larger system in which transportation operates: how the regulation of land influences the cost of housing; how the cost of housing influences trip patterns; how long commutes and low-density development contribute to carbon emissions and climate change by forcing all but exclusive reliance on personal vehicles; how climate change drives the need to reinforce infrastructure and re-think long-established development preferences; and whether and how electrification and greater levels of autonomy may be able to help the Commonwealth to address these challenges.

Playing out against this very complex and interdependent backdrop are the ways in which our transportation ecosystem itself is evolving rapidly. The birth of Mobility as a Service (MaaS) and the advent of car-, bike-, and scooter-sharing are some of the first paradigm-shifting mobility innovations in many decades. Other paradigm shifts that we can only imagine are likely to occur by 2040, but transportation infrastructure will likely remain much as it does today: made up of bridges and roads, rails and airports, and focused on the mass movement of people and goods. How people and goods move and on what types of infrastructure built and managed by what types of entities will determine much about whether and how the Commonwealth will thrive in 2040.

Throughout our work, the Commission has employed scenario planning as a way to envision a range of plausible futures for the Commonwealth. Although common in other types of long-range planning, this method is a relatively new concept in transportation. The Commission did not try to predict the future, nor pretend that the Commission could control all possible outcomes. Rather, Commissioners considered the different directions in which Massachusetts could go and developed recommendations for how to shape a positive future out of uncertainty and rapid change. Scenario planning provides a lens through which to evaluate potential investments, policies, programs, and to test the relative merit of each under different scenarios. Those that could prove efficacious in the greatest number of scenarios are those the Commission recommends. The Commission's goal is to help Massachusetts get to 2040 and beyond as effectively as possible, to be prepared for change rather than overwhelmed by it, and to encourage innovation rather than be threatened by it. In summary, the Commission strove to be resilient, in all meanings of the word.

The Commission members recognize that the opportunity given to this body was an unusual one. Explicitly freed from addressing the demands of today's transportation system, the Commission could peer into the future to see how the current and future generation may live in Massachusetts in slightly more than two decades. Some of those futures are attractive – those in which mobility is easier, commutes are shorter, the natural environment is healthier, and our economy and quality of life are strong – but others decidedly are not. While there are forces that will always exist outside of the Commonwealth's control, leaders and policymakers in the Commonwealth, as well as all residents and employees, have it within their power to bend our future toward healthier and more prosperous paths. Massachusetts is fortunate in its dense, multi-modal transportation system – a legacy left by forward-thinking leaders and citizens who understood the importance of connectivity and mobility – but that system is struggling under the weight of deferred maintenance and unmet needs. The Commonwealth will need to continue to care for and improve the system it has, while also strengthening and expanding it to support the future of mobility. The Commission hopes that the recommendations articulated here will help to provide guidance to 2040.

This report includes both near-term and long-term recommendations and suggested next steps, as the Commission feels the greatest contribution it can make is to encourage action, and not simply to provide policy prescriptions with no meaningful path to implementation. The Commission has used the title *Choices for Stewardship* for this report because this is a generationally important moment, one in which today's leaders can and must act to secure the future for the Massachusetts residents of tomorrow – whether they be born here or newly arrived, no matter their level of education or income or access to power. This call to stewardship is most

urgent in the area of climate change, but it is relevant in many other areas as well. It is our duty to build and nurture a reliable, sustainable, well-maintained, and financed multi-modal mobility system for the future of all of Massachusetts.

Sincerely,

Steven Kadish, Chair

Senior Research Fellow, Taubman Center for State and Local Government, Harvard University

Eileen McAnneny, Vice Chair

President, Massachusetts Taxpayers Foundation

Rebecca Davis

Deputy Director, Metropolitan Area Planning Council (MAPC)

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Secretary, Executive Office of Energy & Environmental Affairs

Executive Orders

Executive Order No. 579: Establishing the Commission on the Future of Transportation in the Commonwealth, issued by Governor Charlie Baker on January 23rd, 2018

WHEREAS, the Commonwealth's transportation system is critical not only to meeting mobility needs but also to supporting economic development and achieving sustainability objectives;

WHEREAS, demographics, climate, and increasingly disruptive changes in transportation technology and business models likely will have a significant impact on the future of transportation in the Commonwealth;

WHEREAS, Massachusetts does not have a statewide, comprehensive transportation blueprint and lacks the foundation needed to create such a blueprint without better understanding how these changes will affect transportation patterns and needs during in the future;

WHEREAS, those same forces could affect the types of capital investments Massachusetts will need and should make as well as the sources of revenue to support such future infrastructure investments in the Commonwealth; and

WHEREAS, this Administration recognizes that input from leaders, experts, and other stakeholders outside of the Administration will help more clearly define future transportation needs and challenges and solutions to those challenges;

NOW, THEREFORE, I, Charles D. Baker, Governor of the Commonwealth of Massachusetts, by virtue of the authority vested in me by the Constitution, Part 2, c. 2, § I, Art. I, do hereby order as follows:

Section 1. The Commission on the Future of Transportation in the Commonwealth is hereby established to advise the Governor and Lieutenant Governor on how to ensure that transportation planning, forecasting, operations and investments for the period from 2020 through 2040 can best account for likely demographic, technological, climate, and other changes in future mobility and transportation behaviors, needs and options.

Section 2. The Commission shall consist of up to 18 members, including a Chair. The members shall be leaders, experts and other stakeholders drawn primarily from outside the Administration. Each member shall have expertise in one or more of the following areas: policy and planning; transportation policy; disruptive transportation technologies; transportation business and mobility models; climate; energy; economic or demographic forecasting; and land use or development. In addition to the external members, the Secretary of the Executive Office of Energy and Environmental Affairs and the Secretary and CEO of the Massachusetts Department of Transportation shall serve as members of the Commission *ex officio*. Each member, including the Chair, shall be appointed by the Governor and shall serve at his pleasure, without compensation, in an advisory capacity, until the report referenced in Section 5 is delivered, whereupon the Commission shall disband.

Section 3. The Commission shall, at a minimum, investigate the following topics that are critical to laying a foundation for understanding anticipated changes in population, employment, and demographics in Massachusetts as well as forthcoming developments in transportation-related technologies, energy use, climate change and other factors that may affect transportation:

1. Climate and Resiliency: What changes will be needed to reduce transportation greenhouse gas emissions consistent with Commonwealth targets for 2040? What kinds of investments will be needed to make transportation infrastructure more resilient?
2. Transportation Electrification: To what extent should the Commonwealth encourage or promote electrification of personal vehicles, transit systems and other transportation systems? What changes might be needed to energy infrastructure to support electrification?
3. Autonomous and Connected Vehicles: Over what timeframe will autonomous vehicles likely be deployed in Massachusetts and under what policy framework? What changes to policy and infrastructure might be needed to support deployment of autonomous and connected vehicles?
4. Transit and Mobility Services: To what extent will “mobility as a service” change transportation in Massachusetts? How will the role of public transportation evolve if on-demand and mobility-as-a-service options become more widespread in the future?
5. Land Use and Demographics: What changes in land use and demographics could either drive or be driven by the types of disruptive climate, technology and business model changes likely to occur in transportation? What other context issues should the Commonwealth consider when planning for its transportation future?

The relevant time frame for this analysis shall be 2020-2040. The Commission and its working groups should develop analyses, assumptions and scenarios that can help inform a common understanding of the future of transportation in the Commonwealth. The Commission and its working groups are encouraged to involve other experts, stakeholders and members of the public in its work through listening and working group sessions or whatever other mechanisms the Commission chooses.

Section 4. The Commission shall be supported by staff from the Governor’s Office, the Executive Office of Energy and Environmental Affairs and the Massachusetts Department of Transportation, and may utilize outside resources to provide consulting and other services as necessary.

Section 5. The Commission shall provide its report and recommendations to the Governor and Lieutenant Governor by December 1, 2018.

Section 6. This Executive Order shall take effect upon execution and shall continue in effect until amended, superseded or revoked by subsequent Executive Order.

Executive Order No. 580: Amendment to Executive Order 579, issued by Governor Charlie Baker on February 5th, 2018

Executive Order 579 is hereby amended in section 2 by striking the words “18 members” and inserting in place thereof the following words: 20 members.

Report Overview

The report is presented in two parts:

- Volume I. Choices for Stewardship: Recommendations to the Meet the Transportation Future
- Volume II. Choices for Stewardship: Background Books – Facts, Trends & Issues

Volume I is presented in three major sections.

- The **first section** details the facts, trends, and issues Commissioners reviewed as they envisioned various scenarios of the future and developed recommendations to the Governor for how to best prepare the transportation system for 2040.
- The **second section** reviews the Commission’s scenario planning process, an exercise that Commissioners used to develop plausible visions of what the future might look like according to variations in two trends: the adoption rate of technological innovation, and the distribution of residents and jobs. This scenario planning work informed recommendation development by providing a framework for considering how different strategies may be applied to different futures.
- The **third section** presents the recommendations the Commission is making. There are five categories introducing a total of 18 recommendations. Each recommendation consists of a comprehensive recommendation providing longer-term guidance with an eye to 2040, why this recommendation is important, and some initial next steps. The first 16 recommendations do not include consideration of necessary resources. The Commission provides such input on governance and resources in the last two recommendations.

Volume II presents five Background Books – Facts, Trends, & Issues on the key topics the Governor charged the Commission to address. Over the last ten months, the Commission has set about to learn as much as possible about the possible disruptive areas-climate and resiliency, transportation electrification, autonomous and connected vehicles, transit and mobility services, land use and demographics - established in the executive orders. The Commission immersed itself in the latest news and reports being developed by academic institutions, industry groups, and think tanks. The Commission hosted a number of local and national experts to speak on disruptive forces, and it held public listening sessions across the Commonwealth. The listening sessions provided an opportunity for Commission members to hear input directly from experts, advocates, and members of the public.

The five Background Books that comprise [Volume II](#) are [posted on the Commission website](#), and include:

1. [Demographics and Land Use](#)
2. [Transit, Active Transportation, and Mobility Services](#)
3. [Autonomous and Connected Vehicles](#)
4. [Climate Change and Resilience](#)
5. [Transportation Electrification](#)

Section One: Facts, Trends, & Issues

The Commission's work is grounded in what was learned through extensive reading of articles and reports, public input both written and from five Listening Sessions, expert presentations, and the knowledge, experience, and expertise of the Commission members themselves. The Commission cast a wide net for information so as not to limit its thinking on the disruptive forces facing Massachusetts' transportation network and on the potential approaches that will best enable the Commonwealth to be ready for them. Early on, the Commission determined that the creation of Background Books (collectively presented as Volume II of this report) on the five key topics charted by the Governor would be an effective way to capture, provide, and present this wealth of information. The Commission believes that this work will be a valuable resource for other states as they consider ways to prepare themselves for the changes that they are sure to face in the future.

This section of the report summarizes the information presented in [Volume II](#).

Key Acronyms

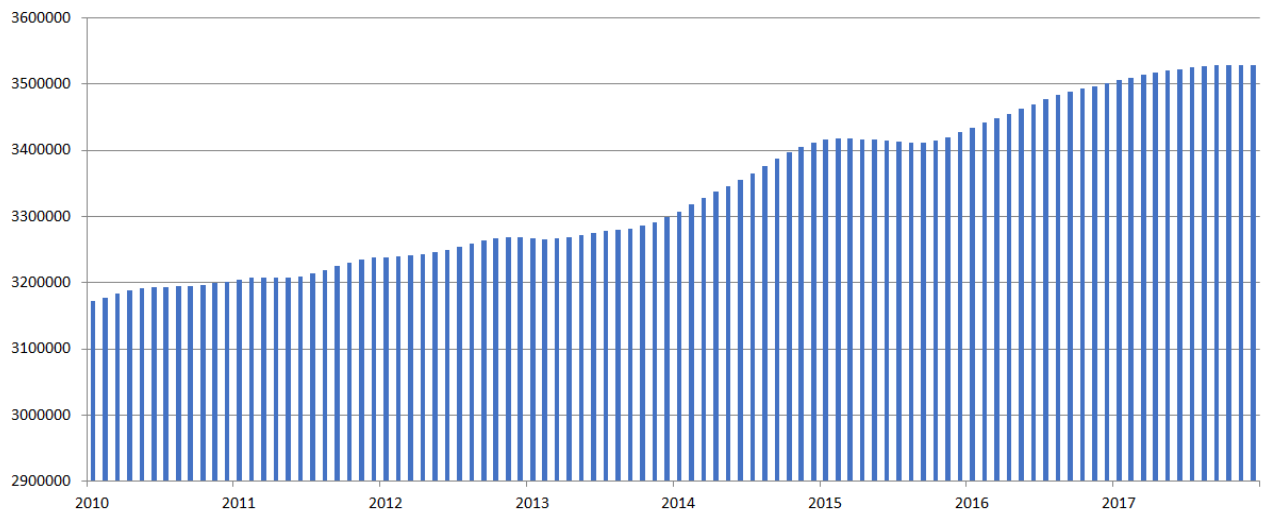
- AV- Autonomous Vehicle
- C/AV- Connected/Autonomous Vehicle
- CV- Connected Vehicle
- EV- Electric Vehicle
- GHG- Greenhouse gas
- GWSA- Global Warming Solutions Act of 2008
- ICE- Internal Combustion Engine
- MaaS- Mobility as a Service
- ODM – On-Demand Mobility
- RGGI- Regional Greenhouse Gas Initiative
- Ride-share – Covers trips that are shared with additional passengers, including shared ride-hailing services offered through TNCs. Among the most traditional forms of ride-sharing are carpooling and public transportation
- Ride-hailing – Includes a range of companies and services that provide on-demand mobility services. Ride-hailing includes traditional taxis and car or van services, but also digital or web-based services like TNCs
- SOV- Single Occupancy Vehicle
- TNC- Transportation Network Company, such as Uber or Lyft
- TOD- Transit Oriented Development
- ZEV- Zero Emissions Vehicle

Demographics and Land Use

As documented in the Demographic and Land Use Background Book, Commissioners learned about several demographic trends in Massachusetts with potentially major implications for the transportation network of 2040 and could profoundly impact how transportation services are delivered.

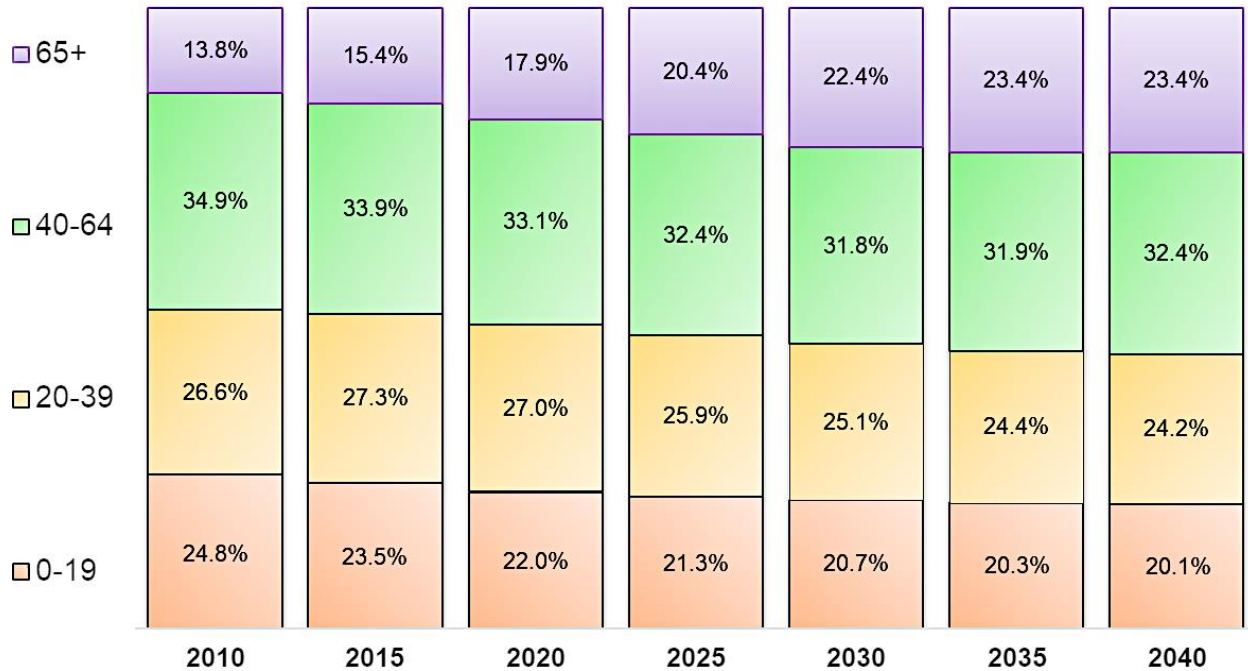
According to population projections, the state is expected to gain roughly 600,000 residents between 2018 and 2040. This is equivalent to adding another city the size of Boston to the state, but in a period of just over 20 years. The state workforce has already grown by over 350,000 jobs since 2010, and forecasts show that this job growth is expected to continue. This expected influx of workers and residents has far-reaching implications, but most relevant for the purposes of this report are the impacts to the Commonwealth's often overextended transportation network.

Employment in Massachusetts: 2010-2017



Source: see Demographics and Land Use Background Book in Volume II

Massachusetts' population is relatively older in age when compared to other U.S. states. The Commonwealth has a slightly larger share of people aged 65 and older than the U.S. average, and the number of Massachusetts residents who are 65 or older grew by 20 percent between 2010 and 2017. Projections show that older residents are poised to be an even larger share of the state population in 2040 than they are now, and are likely to remain in the state's workforce longer than previous generations.

Massachusetts Projected Population Distribution by Age Group: 2010-2040

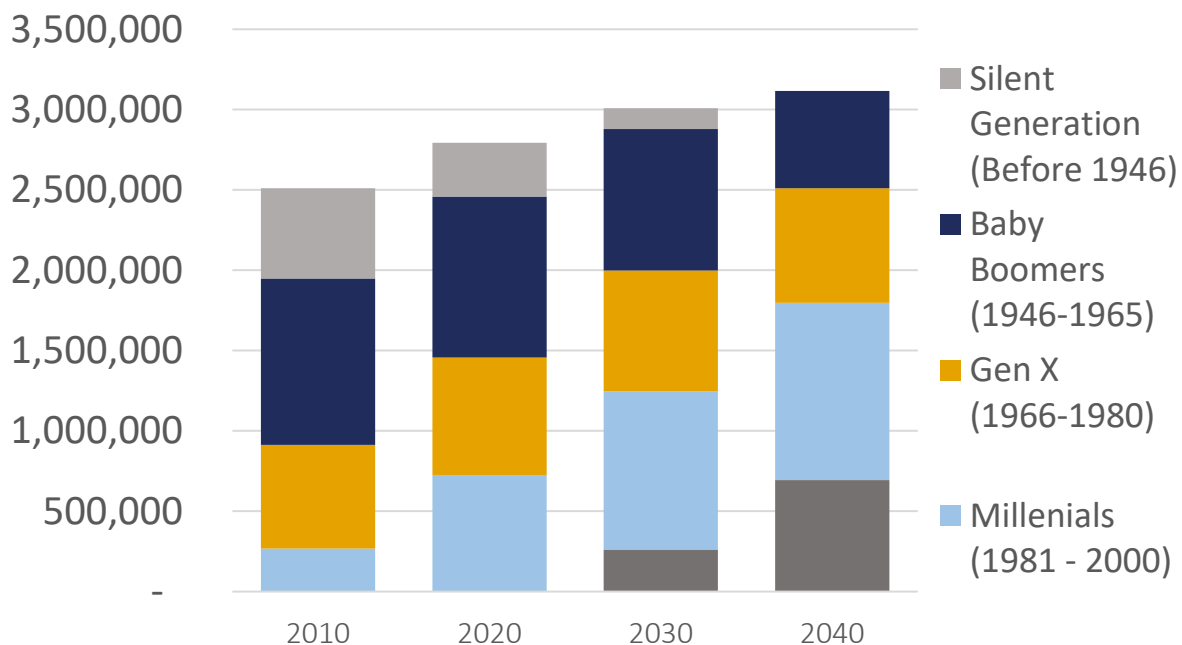
Source: see Demographics and Land Use Background Book in Volume II

The growing number of older adults will be a part of both the regular commuting and non-work trips that are made. Currently older adults do not tend to use ride-hailing and new mobility travel options at the rate of younger adults. However, by 2040 ride-hailing trips will be expected to have been a regular part of the lives of the millennial and other generations for quite some time. Older adults are currently less likely to live in central cities. Thus, it is important to maintain access to more traditional and mainstream modes alongside new ones to accommodate the needs of users at every age.

The Massachusetts workforce is also expected to see year-over-year growth for the foreseeable future. The Millennial generation, people born between 1980 and 2000, are currently the workforce's largest generational cohort, and their numbers are expected to grow. The Millennial influence has been undeniably strong on cultural, social, and economic behaviors. Millennials are among the most prolific adopters of new technology innovations and behaviors, including ride-sharing and active transportation options like biking and walking, and that subsequent generations may have similar preferences. However, it is unclear how much of Millennial behaviors reflect true generational and cultural shifts in preferences, and what parts of their behavior are a function of affordability. Some studies suggest that as Millennials age, they will show more traditional housing and travel preferences.

Net Labor Force Change by Year of Birth: 2010-2040

Source: see Demographics and Land Use Background Book in Volume II

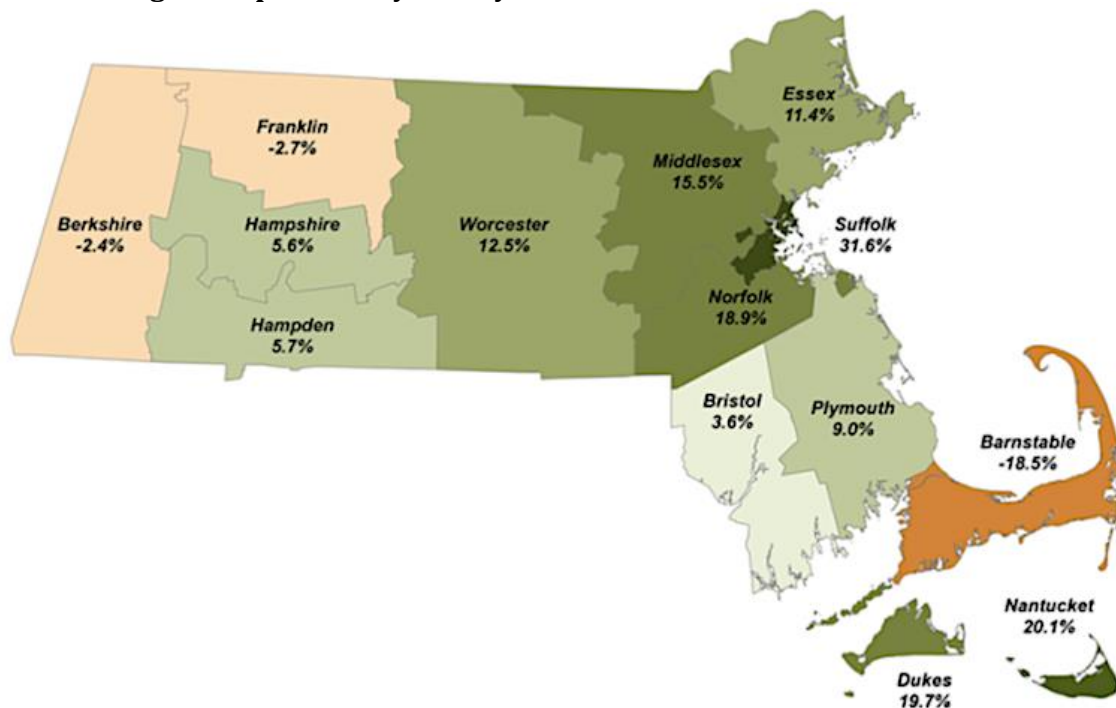
Householders by Generation in Massachusetts: 2010-2040

Source: see Demographics and Land Use Background Book in Volume II

Population growth in Massachusetts is highly concentrated in the eastern part of the state. While Greater Boston alone makes up 45 percent of the state's population, it accounts for 67 percent of population growth since 2010. And growth is even more concentrated in the urban core, close to where the jobs are: Greater Boston region is one of a minority of metropolitan areas in the US where the primary city growth rate is higher than the suburban growth rate. Communities with high-frequency subway service accounted for 42 percent of Massachusetts' net job growth in the last decade, up from only six percent in the previous decade for those same communities. Future

projections for the state exhibit this uneven growth trend: communities in Greater Boston and Central Massachusetts are expected to grow, while Berkshire and Franklin counties in Western Massachusetts and Barnstable County on the Cape are expected to contract over time.

Percent Change in Population by County: 2010-2040



Source: see Demographics and Land Use Background Book in Volume II

This data reinforces that there is a diversity of needs across the state, especially with respect to transportation services and infrastructure.

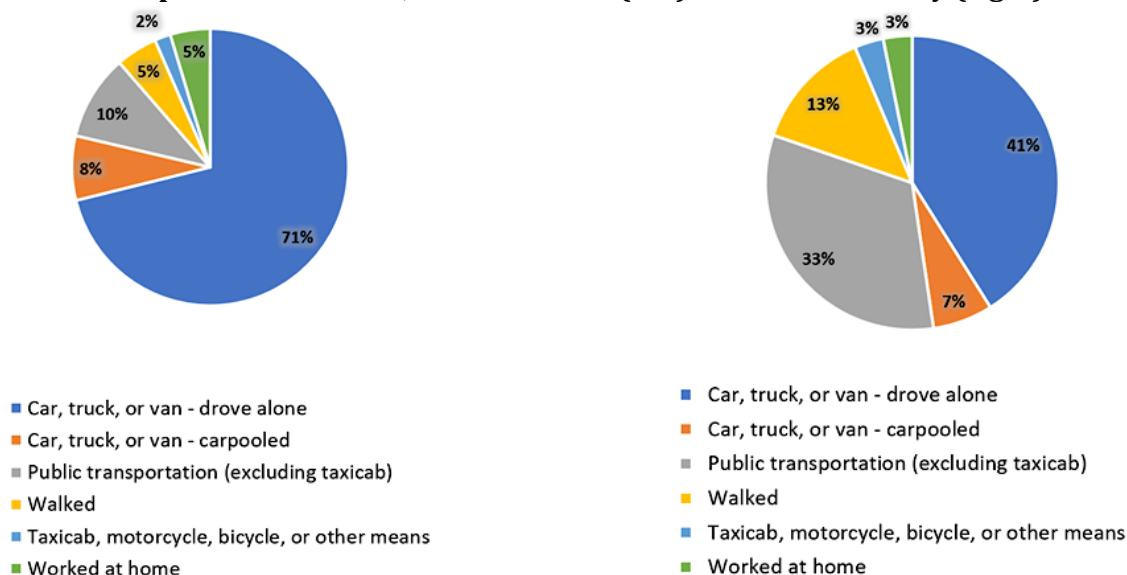
Transit, Active Transportation, and Mobility Services

The Transit, Active Transportation, and Mobility Services Background Book outlines trends among these travel modes and how travel behaviors are changing as a result of fundamental shifts in how transportation services are being offered.

Public transit ridership is down on the Massachusetts Bay Transportation Authority (MBTA) and most of the state's Regional Transit Authorities (RTAs). This trend is similar to most public transit systems in the United States, but ridership trends are far from uniform. While ridership on the MBTA subway lines and buses are down, Blue Line and commuter rail ridership has increased since 2015, and ridership in the MetroWest RTA is up 11 percent between FY17 and FY18. Many towns in Massachusetts – mainly in the central and western parts of the state – are not served by any public transportation at all.

Transportation network companies (TNCs) like Uber and Lyft have become mainstream mobility options, especially in urbanized parts of the state and country. Although they represent a small fraction of trips made they are growing in use. Car-sharing and bike-sharing are now common as well, and the newest micro-mobility entrants to the transportation marketplace - e-scooters - have recently found a home in some Massachusetts cities and towns. However, the availability and use of these services made possible by new transportation technologies is not uniform by geography nor generation. In Massachusetts, these new mobility options are primarily limited to Greater Boston and other large and medium sized-cities. A recent report on ride-hailing by the Metropolitan Area Planning Council (MAPC) shows that TNCs are almost entirely used by Millennials and those younger. Many small towns have almost no TNC activity.

Means of Transportation to Work, Massachusetts (left) and Suffolk County (right): 2016

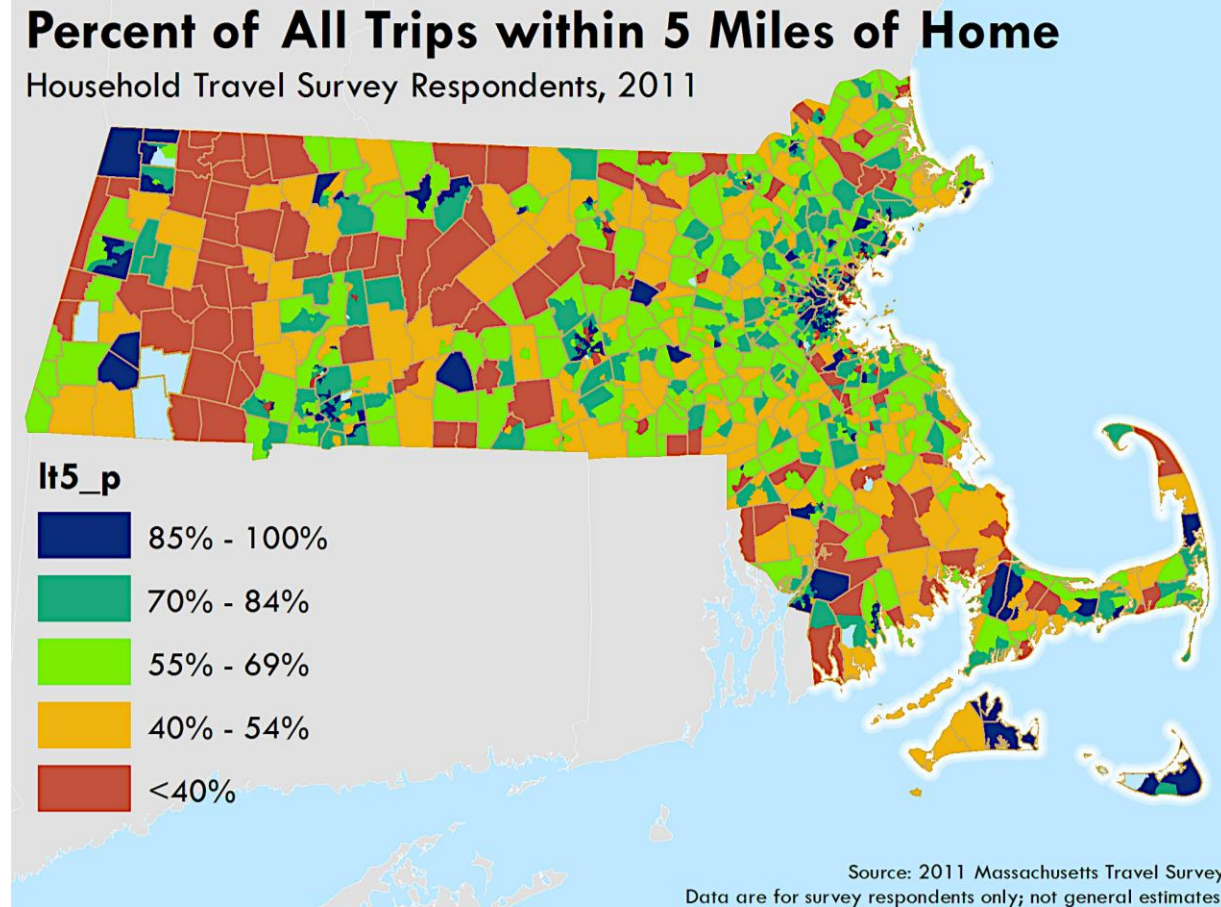


Source: see Transit, Active Transportation, and Mobility Services Background Book in Volume II

Active transportation – meaning biking and walking for travel rather than recreation– is also becoming a more preferred and viable option among subsets of the population. The number of commuters from Suffolk County who either biked or walked grew by 14 percent between 2010 and

2017. Trips via bike-share services, which include commuting as well as other kinds of travel, have seen growth in the Boston region; bike-sharing services are poised to grow in Western Massachusetts where they were recently introduced.

Percent of All Trips Within 5 Miles of Home



Source: see Transit, Active Transportation, and Mobility Services Background Book in Volume II

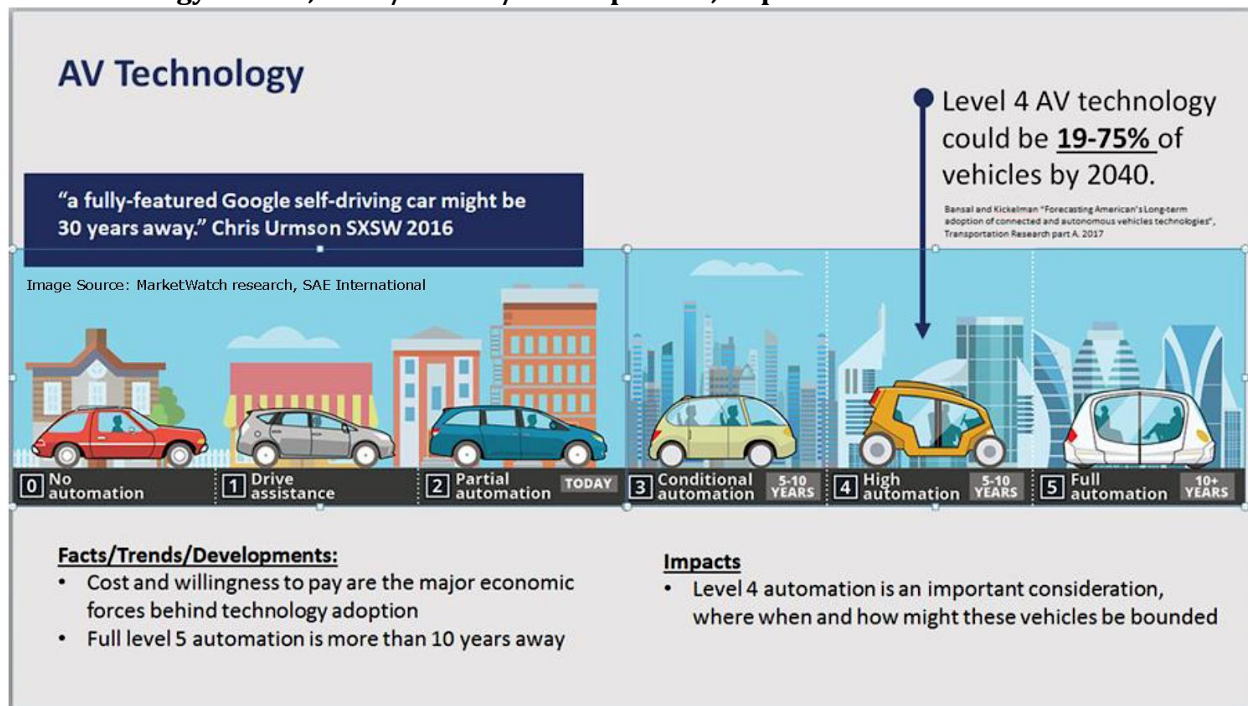
Access to a wide variety of transportation services and mobility options is core to the concept and related technology known as Mobility as a Service, or MaaS. MaaS refers to a new multi-modal mobility marketplace that integrates various forms of transportation options. Examples of MaaS include on-demand ride-hailing services, app-enabled taxi services, bike-sharing, car-sharing, and scooter-sharing. There are some MaaS services that integrate all types of transportation modes, both on-demand and scheduled services, including public transit (trains, subways, buses) and even car rentals into a single platform where users can select their needs and pay-as-you-go or pay by subscription. Primarily available in Europe, there are some North American cities that feature integrated MaaS platforms.

It is undeniable that there are more mobility options available to people than ever before, especially to urban dwellers who live in areas served by public transit. But more than adding to the relative convenience of urban travel options, new technologies and changing needs and preferences provide an opportunity to respond to transportation challenges outside of high-density communities as well.

Autonomous and Connected Vehicles

The Autonomous and Connected Vehicles Background Book explores the ways in which Connected and Autonomous vehicles (C/AVs) are just beginning to affect the transportation marketplace. Connected vehicles are cars and trucks that can connect to other devices including road and traffic infrastructure, via either the Internet or other communications signal. The 'autonomy' of vehicles describes the level of self-driving automation enabled by the vehicle's technology. There are six 'levels' of automation, ranging from Level Zero (no automation) to Level Five (full automation). Most cars on the road are Level Zero or One (drive assistance, including cruise control) but more and more manufacturers are offering vehicles with Level Two features (partial automation, including simultaneous cruise control and lane centering). Levels Four and Five refer to a level of autonomous capability that do not require the intervention of a human driver. Connected vehicles may or may not have automated capabilities. Connected vehicles that can communicate with other vehicles and/or the infrastructure around them can be used to enhance safety (for example, collision warnings) and provide data on traffic flow and real-time transit information to inform optimized routing or traffic signaling.

AV Technology: Levels, Facts/Trends/Developments, Impacts

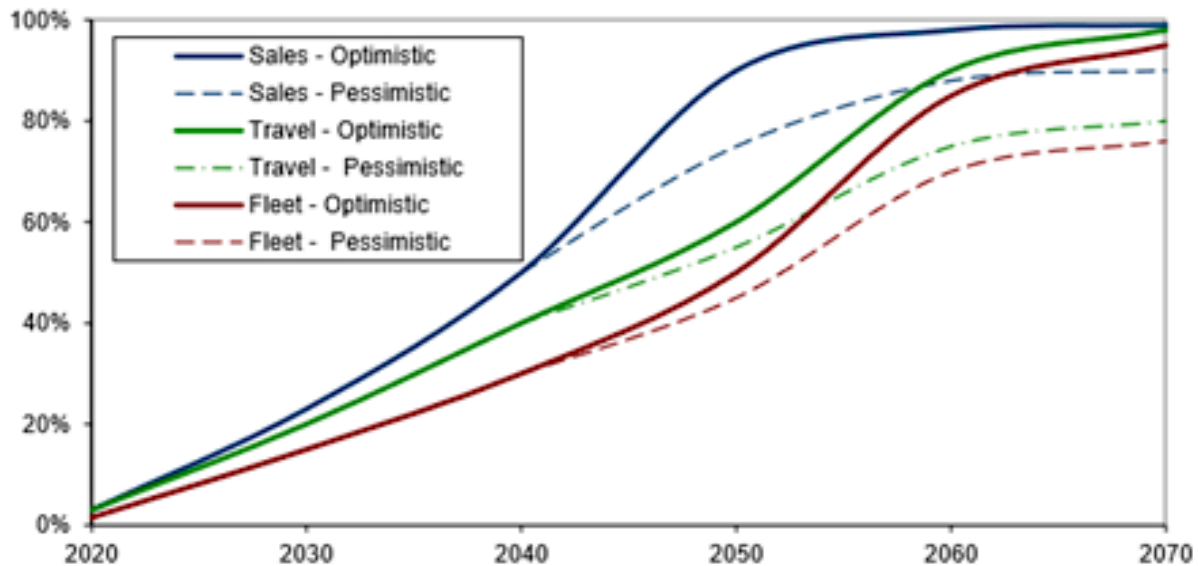


Source: see Connected and Autonomous Vehicles Background Book in Volume II

There is pronounced anticipation about how C/AVs could change our economy and transportation networks. Initial reaction by policymakers around the globe has been positive, indicating that C/AVs are likely to see widespread adoption in the coming years. To date, at least 42 states have enacted legislation and/or signed executive orders that address C/AV testing and deployment, including Massachusetts. Automakers and technology companies are making substantial investments in developing connected and autonomous systems, but it will still be some time before most vehicles on the road are fully autonomous. Projections show that anywhere from 19 to 75 percent of all vehicles on the road could feature Level Four automation (high automation, with full self-driving capabilities in most but not all scenarios) by 2040. That is a wide range, and the

mainstream adoption of AV's is far from certain. However, this evolution has the capacity to have profound impacts on the Commonwealth's transportation system.

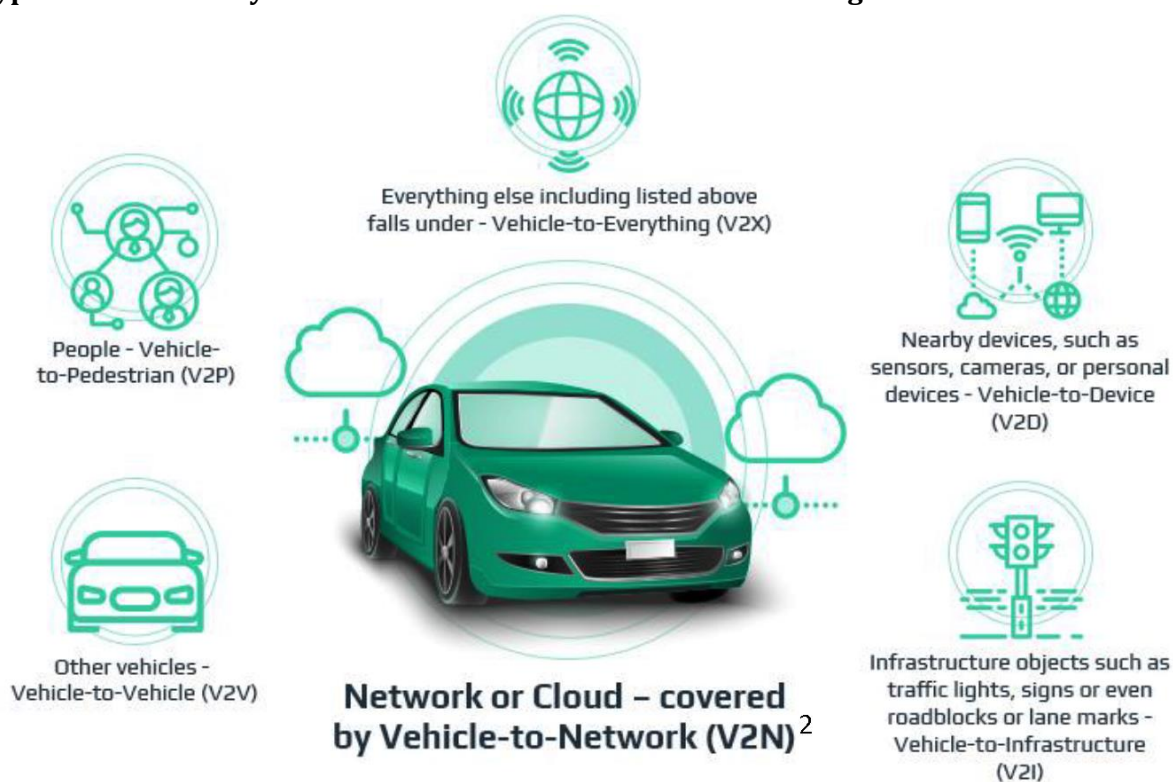
Autonomous Vehicle Sales, Fleet, and Travel Projections: 2020-2070



Source: see Connected and Autonomous Vehicles Background Book in Volume II

C/AVs have the potential to radically shift transportation and mobility and have a myriad of implications for transportation broadly. Service industries with driving functions, such as public transit, for-hire ride services, commercial trucking and logistics will be impacted, each in different ways. Ride-hailing and trucking or freight companies are particularly interested in C/AV technologies because of the labor cost savings implications. Safety considerations might change as well, with over 90 percent of all crashes caused by human error. Many tests have shown that driver-assist features like collision avoidance have helped to reduce crashes. Roadway features that can be introduced to accommodate C/AVs, like broadcasting Signal Phasing and Timing (SPaT). This is a technology that communicates information directly from transportation infrastructure to cars and has the potential to have major implications on roadway safety for connected vehicles, regardless of their level of autonomy.

Types of Connectivity Available via Vehicle-to-Network Technologies

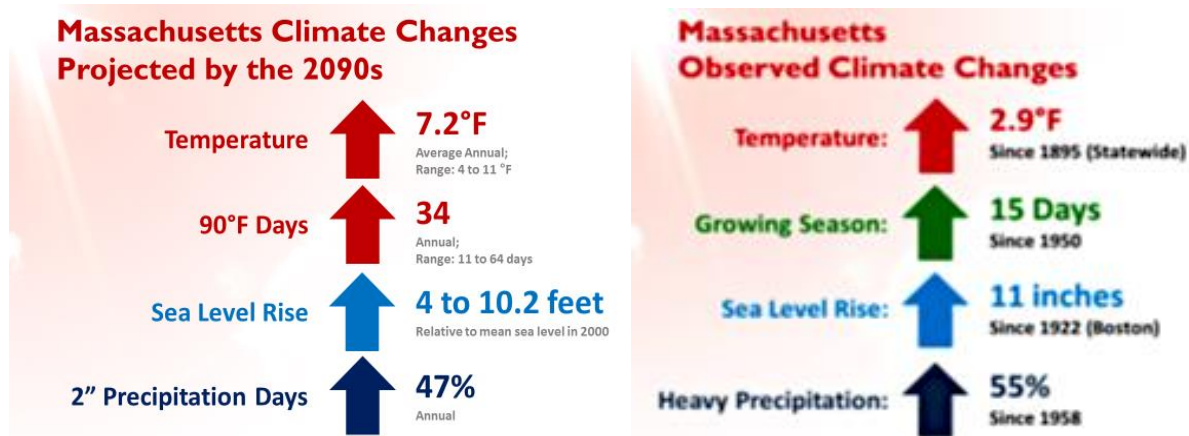


Source: see Connected and Autonomous Vehicles Background Book in Volume II

C/AVs also have implications for traffic congestion. While on the one hand, C/AVs are likely to bring more cars on the road by making driving safer, easier, and more convenient, autonomous vehicle precision can safely bring cars closer together and allow for narrower lanes. Similarly, while smoother driving could improve throughput and stability of traffic flow, new fleets of empty cars driving on roadways could also increase congestion.

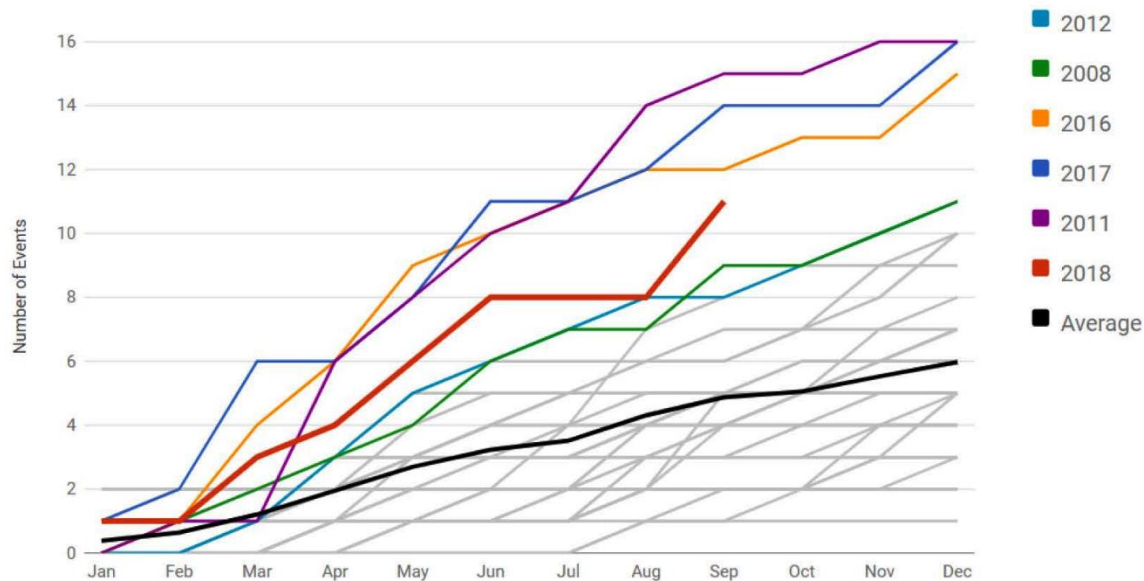
Climate Change and Resilience

In the Climate Change and Resilience Background Book, the relationship between transportation and the environment is well-documented. Climate change is one of today's most pressing issues. The number and frequency of volatile and extreme weather events have increased over the last several decades, and are having noticeable effects on our environment, our infrastructure, our economy, and our well-being. A recent report of the Intergovernmental Panel on Climate Change (IPCC), a body of the United Nations and leading authority on climate science, warned that the impacts of climate change are happening both sooner and more intensely than originally thought.



Source: see Climate Change and Resilience Background Book in Volume II

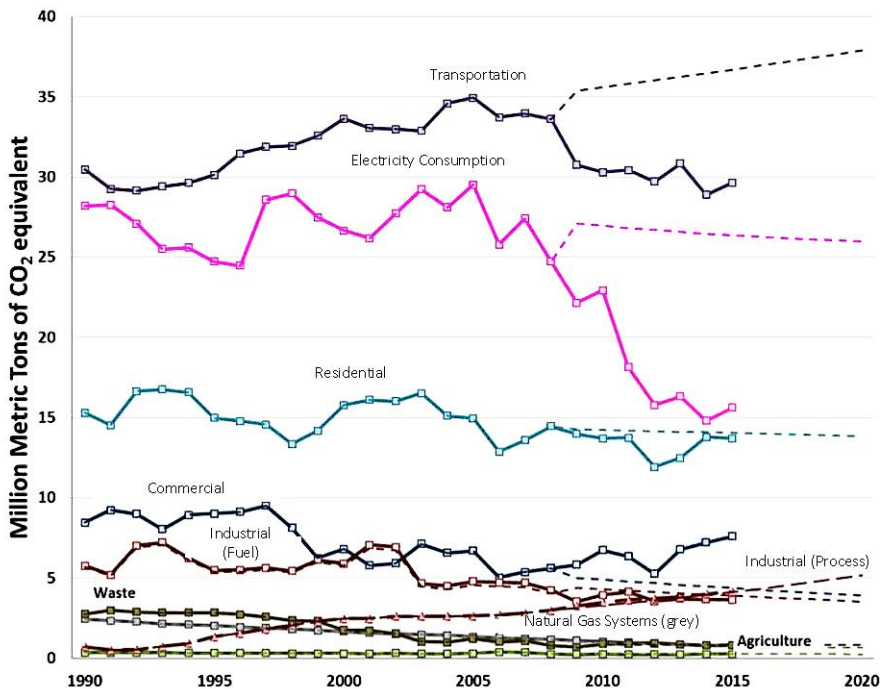
The issue is not conceptual: the effects of climate change can be felt at home in Massachusetts right now. In the 27-year period since 1991, Boston has had 21 weather events trigger federal or state disaster declarations. A 2017 special report found that temperature in the state has risen an average of 2.9 degrees since 1895, and the Fourth National Climate Assessment report released in November 2018 projects that by 2035, the Northeast will see the largest temperature increases in the contiguous United States. This is not a minor shift: heat waves can easily become public health emergencies, and rising temperatures have major impacts on agriculture as they affect crop production, crop yields, and farm management overall. Since 1950, 15 days have been added to the state's growing season, and heavy precipitation incidents have increased 55 percent since 1958. Climate change impacts triggered by increasing GHG levels affect coastlines and leave them vulnerable to flooding and erosion, which makes Massachusetts particularly vulnerable. There were 57 flood days in Massachusetts between 2005 and 2014 – and nearly three quarters of them were directly connected to climate change. Boston harbor has already experienced a sea level rise of eleven inches since 1922; some studies predict a 6 to 10 foot rise in sea levels by 2090.

1980-2018 Year-to-Date U.S. Billion-Dollar Disaster Event Frequency (CPI-Adjusted)

Source: see Climate Change and Resilience Background Book in Volume II

Transportation networks and mobility are not immune to extreme weather events. People travel differently in extreme weather. For example, they tend to be more cautious when driving or rely more heavily on public transit. At the same time, extreme weather conditions can cause severe damage to transportation infrastructure, including warped rail lines and blocked and damaged roads. Extended cold periods also affect the ability to clear snow and ice from roadways and other infrastructure. This impacts both the safety and utility of the transportation network by reducing mobility for people and goods. Bad weather is to blame for 15 percent of all roadway congestion, and anywhere from 25 to 69 percent of all United States air travel delays. The winter of 2014-2015 is a recent memory for many Bay Staters, who no doubt recall the many highway closures and the shutdown of the MBTA because of unprecedented snowfall.

Massachusetts GHG Emissions from Fuel Combustion (by Sector)



Source: see Climate Change and Resilience Background Book in Volume II

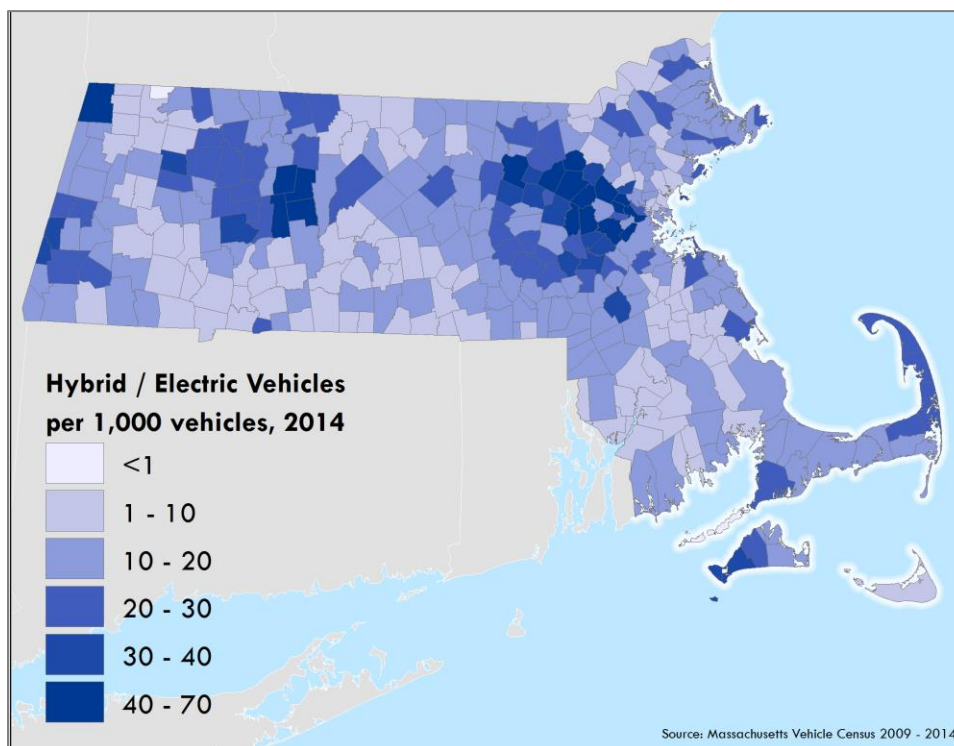
Transportation is not only affected by climate change – it is now the largest and fastest growing emitter of greenhouse gas emissions. Almost 30 percent of all GHG emissions in the United States came from the transportation sector in 2016 – and in Massachusetts, almost 40 percent of GHG emissions in 2015 came from transportation infrastructure and vehicles, with nearly half of the contribution coming from passenger vehicles alone.

Moreover, transportation's contribution to GHG emissions is growing: projections show transportation emissions will continue to increase in the state, even as other sectors' contributions are leveling off or decreasing. It is unclear how these projections will change over time with the rise of new transportation technologies like C/AVs and TNCs, which simultaneously introduce the potential for more car and ride-sharing, but also may generate more GHG emissions, unless there are requirements for zero-emission vehicles.

Transportation Electrification

The Transportation Electrification Background Book provides key facts and trends about electric vehicles (EVs), which are among the most recent innovations in the automobile marketplace. Globally, two percent all new car sales in 2016 were electric. Adoption has been slower in the United States, where just over one percent of all domestic vehicles sales in 2017 were electric. Massachusetts has shown adoption rates somewhere between the United States and the rest of the world: 1.4 percent of all light vehicles sold here in 2017 were electric, and 12,000 EVs were registered with the Registry of Motor Vehicles (RMV) that year.

Hybrid/Electric Vehicles per 1,000 Vehicles in Massachusetts: 2014



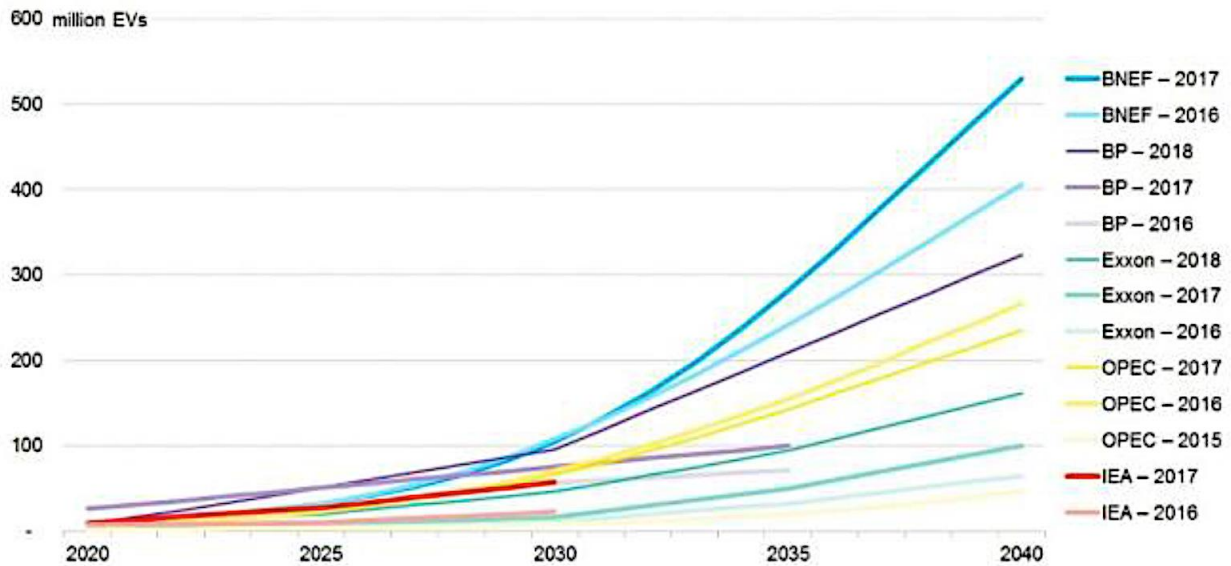
Source: see Transportation Electrification Background Book in Volume II

Although U.S. EV adoption has lagged the rest of the world, projections are frequently revised to reflect greater adoption rates. For example, over the course of one-year, Bloomberg New Energy Finance (BNEF) revised their projection to add over 100 million vehicles to the number of EVs they expect to be on the road in 2040. Projection revisions largely stem from the development of cheaper batteries and lower maintenance costs that make EVs more affordable. In addition, several manufacturers are developing Fuel Cell Electric Vehicles (FCEVs) – an advancement over ‘traditional’ battery electric vehicles (BEVs). Some experts believe FCEVs may reach cost parity with BEVs by the 2030s, and may be a better solution for heavier vehicles and/or longer-distance travel.

While EVs are believed to have cost and maintenance advantages for consumers over the course of their useful life, their primary benefit is environmental. EVs emit far less than conventional vehicles, especially when grids that rely on renewable energy rather than carbon-based fuels to power them. In terms of emissions impact, an EV in New England is equivalent to achieving a fuel economy of 103 miles per gallon in a conventional vehicle, and national research shows that

midsize EVs are estimated to reduce GHG emissions by 51 percent compared to midsize gasoline-powered vehicles.

How Electric Vehicle Fleet Size Forecasts Have Changed Over Time



Source: see Transportation Electrification Background Book in Volume II

While EVs reduce GHG emissions, there are environmental considerations to keep in mind, primarily with respect to reliance on the electric grid. EV's need an electrical power source in order to run. In terms of energy consumption, adding an EV to a neighborhood is equivalent to adding an extra home. While this could be a concern in Massachusetts as capacity has been an issue in the past, this concern could be mitigated by financial incentives offered by utilities that could level-off demand, and other technology developments.

One of the biggest questions with respect to EVs is how owners will access the grid and charge their vehicles. Most EV owners charge their vehicles at home, but a future with widespread adoption means that sufficient charging stations and infrastructure will be necessary. If the charging trends of today continue, consideration will have to be given to how to address vehicle owners who do not have garages at their homes. While Massachusetts is among the top ten states in terms of the number of charging stations and outlets presently available, more work needs to be done to provide a sufficient charging infrastructure to support vehicle electrification. The introduction of fast-charge infrastructure and faster charging capacity on vehicles and other such technological advances have the potential to dramatically change charging needs. For example, technology is being developed to charge a car at 400kW of power, which translates into about 250 miles of range in twelve minutes. Regardless of how the technology evolves, basic infrastructure will be needed to ensure that charging sites and stations can be easily integrated.

Section Two: Scenario Planning

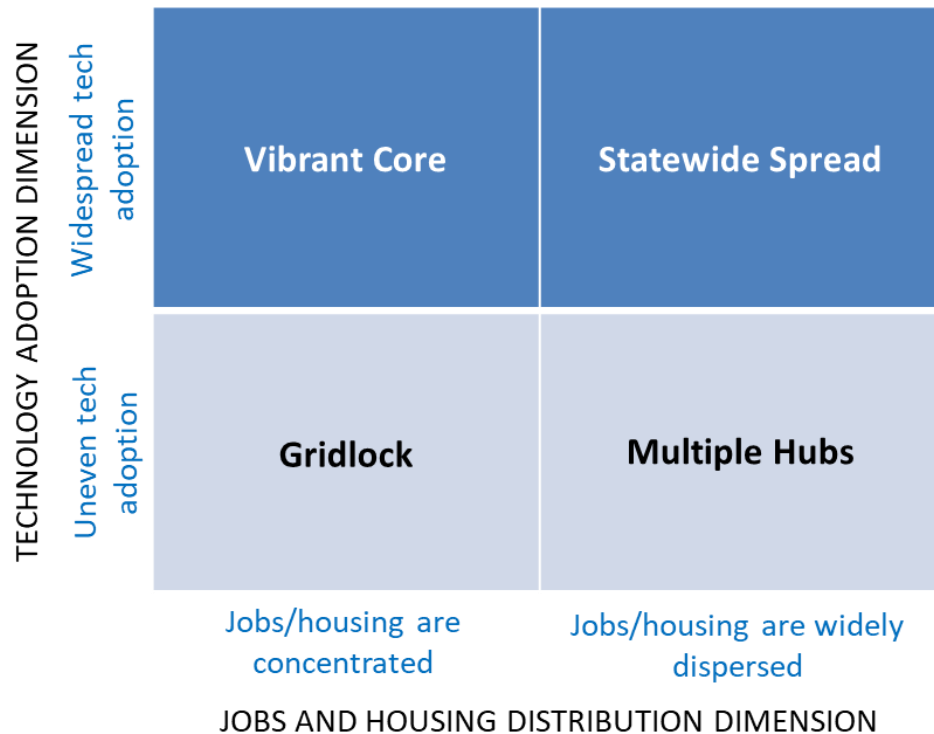
Our Approach

Governor Baker’s Executive Order No. 579 asked the Commission to provide recommendations to prepare the transportation system for what the future may be in Massachusetts in 2040. Scenario planning is an exercise used by the Commission to process an enormous amount of information about trends in demographics, technology, electrification, transportation services, land use and the economy, and to help describe plausible future scenarios. MassDOT uses this tool in its planning work, as suggested as a “best practice” by the National Cooperative Highway Research Program (NCHRP) Report 750 Foresight Series. The Foresight Series encourages transportation policy makers to adopt scenario planning as a practical tool for considering future investment in mobility needs. NCHRP’s Implementation Support Program supported our scenario planning work for this Commission.

Following hours of scenario planning meetings and after evaluating many potential future trends, the Commission chose two major trends which will shape people’s mobility options and needs and used these two trends to create plausible scenarios: technology adoption and jobs and housing distribution.

Technology adoption, and whether it is available and adopted uniformly by people across generations or geographical areas, will strongly influence travel options and needs.

The distribution of jobs and housing will impact travel options and needs - in 2040, in other words, it will matter whether the increase in jobs and housing is concentrated or more widely dispersed.



The following pages present detailed descriptions of each scenario.

Scenario 1: Gridlock

Headline

The fast growth of Boston and its surrounding municipalities has continued, but without expansion of existing transportation capacity.

Description

It is 2040. Employers are frustrated with Boston's high-density commercial and housing environment, and its residents, who once embraced city-oriented life, are discouraged by traffic and inconsistent public transit service. The Greater Boston region clings to its place as the center of business, but some jobs and people are beginning to look outside the city's core and outside the state. Despite MaaS opportunities inside the core, uneven adoption of transportation technologies and new mobility services exacerbates congestion, GHG emissions, social inequities, and conflicts between public, private, and new mobility transportation services. The concentration of new mobility and transportation technology innovations inside Greater Boston and maintenance of historical status quo transportation options have led to a wide disparities in access to transportation, and opportunity in the Commonwealth.

The constrained and expensive supply of city real estate - exacerbated by the loss of some areas to coastal flooding and heavy storm surges - has already pushed some households and businesses to more affordable homes or commercial space to Greater Boston's outer edge. Difficult commutes increase. What constitutes a long commute has been redefined to more than double that of 20 years ago. Widespread adoption of new transportation technologies like ride-hailing was not realized, and a lack of consistent investment in people, capital, and operations has increasingly meant that traditional public transit is the sole option for those who do not own or have access to a privately owned vehicle. The few other regional job hubs in the state face the same threats as Boston, and many rural communities and some cities located elsewhere in the state begin to lose significant population as working-age residents relocate for better economic opportunities. The concentration of people and jobs in coastal zones makes infrastructure resiliency in the face of climate change a significant challenge.

Highlights

- Jobs and housing growth continues primarily in Greater Boston.
- Alternatives to single occupancy vehicle (SOV) travel like ride-sharing and vehicle-sharing are not as convenient, reliable, or available as projections had suggested.
- Investment in active transportation infrastructure is limited and considered supplemental to traditional infrastructure needs.
- Choking traffic congestion and unreliable public transit are causing residents and employers to look for opportunities outside of Greater Boston and the state in general.
- The cost of housing and commercial property push many people and businesses to the core edges of metro regions, and sometimes beyond.
- Some rural towns and cities located further from Boston shrink as they lose working age population.

Scenario 2: Vibrant Core

Headline

Greater Boston continues to grow, supported by new transportation technologies and systems that facilitate the success of a vibrant and livable metro region.

Description

With employers who still value face-to-face interaction over remote work environments and a society that embraces city-oriented life, the Greater Boston region has absorbed most of the state's jobs and population growth. Many communities in the region, especially those in the Boston core, feature high-density, walkable commercial and housing environments. Ubiquitous adoption of transportation technologies such as connected, autonomous, electric, and shared vehicles support the achievement of GHG reduction, congestion reduction, and social equity-related goals.

The constrained supply of real estate in the core, exacerbated by managed retreat from some neighborhoods due to coastal flooding, means that some are pushed to more affordable homes or commercial space in the suburbs or at the region's edge. However, even when dislocations mean longer commutes and distances between destinations, trips are made convenient via reliable transit, active travel, micro-mobility, and MaaS options. The proliferation of safe and reliable multi-modal options has improved both economic opportunities and quality of life for those both in the region and outside of it: more people are walking; electric bikes, scooters, and other similar modes are common; and urban rail and bus rapid transit have created new travel patterns within the I-495 belt. Advancements in mobility technologies and an expansion of the services offered as part of a public transit network have resolved many first/last mile issues and the challenges of providing transit in low-density areas. Technology-adept Millennials have significantly lower rates of car ownership than the Boomers, and they and their children often forego SOV travel for ride-sharing.

Communities within the extended Greater Boston region have grown, but more rural communities have shrunk as they have lost college graduates to places with more advanced economic opportunities. These trends in economic and residential density have created a disparity between the urban-focused communities in the state, which feature most of the working population, versus rural and some suburban areas, which are home to increasingly higher percentages of older residents.

Highlights

- Jobs and housing growth continues primarily in Boston's core and close-in communities, especially those with MBTA service. Some rural communities located further from Boston shrink as they continue to lose population.
- However, the cost of housing and commercial property push some people and businesses to more affordable areas further from the Boston-centric core, effectively growing the footprint of the urban core to the Route 495 and beyond.
- Ubiquitous adoption of technology advances in C/AVs and in electric vehicles of all types, supported by a sophisticated clean energy demand/supply grid, combined with a shared approach to MaaS, support a vibrant, livable, and mobile core on target to meet GHG and related goals.
- Reliable public transit, MaaS, and micro-mobility options provide trips around the core and beyond.

Scenario 3: Multiple Hubs

Headline

High-density growth takes place in several cities and their regions throughout the Commonwealth. Increased density and expanded mobility options create the opportunity to take advantage of lower cost housing and promotes job creation outside of the Greater Boston core.

Description

More dispersed growth occurs in and around regional core cities because Greater Boston and Boston itself is crowded, expensive, vulnerable to extreme weather, and hard to travel in and through. Many of these regions feature amenity-rich transit and active transportation-conducive land uses on top of affordable business and residential real estate. Commercial and residential development is generally concentrated in the core cities of different regions, but downtown development drives growth (and some sprawl) in less dense suburbs. A multiple hubs scenario also predicts a greater supply of relatively affordable housing in several opportunity-rich areas outside of Greater Boston.

These regional economies are supported in many places by RTAs to implement best practices that make transit fast, convenient, desirable, comfortable, and competitive with travel by personal vehicles. While new transportation technologies and mobility options are commonplace within vibrant regions, the availability and adoption of new or alternative travel options is uneven outside of them. Connectivity between regions is strong but the most frequent and reliable mobility services are concentrated along key corridors. Some of the congestion issues most associated with getting in and around Boston have manifested in these growing regional hubs and MassDOT and local municipalities are actively addressing.

Highlights

- Jobs and housing growth happens in regional hub cities with their own economies, cultural identities, histories, and challenges.
- The commercial and housing development generally concentrates in the core of the regional hub cities and also drives growth (and some sprawl) in less dense suburbs.
- In these regions, there is the adoption of C/AV and MaaS with travel by shared rides, and many of the RTAs have come together with the private sector to adapt a new paradigm of serving lower density hubs and travel between them. Outside of these regions, adoption of new transportation technologies and new mobility options is more limited due to long-standing infrastructure challenges and the aging of populations in rural and low-density communities.
- Some regional hubs serve seniors, those with limited mobility, and rural communities better than others. Because economic development is distributed throughout the state, most rural communities are not far from opportunities for jobs, education, shopping, healthcare, etc.
- The growth in electric vehicles of all types is supported by a sophisticated clean energy demand/supply grid, which moves the Commonwealth toward meeting its GHG emissions targets and related goals. However, vehicle miles traveled (VMT) has increased as the rise of C/AVs and EVs both incentivize the use of and mitigates some negative impacts of SOV travel.

Scenario 4: Statewide Spread

Headline

Technology has transformed not just transportation but every aspect of people's lives, including work, communication, commerce, and service delivery. This widespread use of technology allows for more choice for those with access to technology, while potentially disadvantaging others.

Description

An economy driven increasingly by digitization, robotics and mechanization, and telecommunications changes how we get to work as well as how we access services and receive or deliver goods. Adoption of some new technology innovations is high, and those related to autonomous, connected, and electric vehicles is widespread. However, reliance on ride and vehicle sharing including MaaS and public transit is low outside of Greater Boston and other regions with a critical mass of people and jobs, because the marginal cost of running transit service remains high in those areas against increasingly more affordable C/AVs and EVs. Some RTAs that have faced increased competition have even succumbed to pressures from ubiquitous autonomous vehicles. Inside the Greater Boston core, the MBTA has effectively been forced to expand by including new mobility options such as shared rides as well as active transportation options like e-bikes and e-scooters alongside traditional buses, subways, and paratransit vehicles in order to remain competitive.

Population and job growth is dispersed throughout the state, as the importance of physical location has diminished via increased reliance on telecommunications networks. Central cities have lost some of their significance as spatial concentration is not as necessary for places to be economically competitive. Workers now have the option to live in less expensive, low-density suburbs and rural areas, which supports home-based lifestyles, as more work and services move online and the increase in severe weather keeps people indoors more often. Climate change makes some coastal locations and inland, flood-prone areas unviable for residents and businesses; people are frequently dislocated, but new connections are forged between regions as population spreads out. Social equity is an increased concern as many workers displaced by technology face ongoing high rates of unemployment; and seniors and others with more limited mobility options are "stranded" in place, needing access to affordable housing and transportation to critical services and jobs.

Highlights

- Jobs and housing growth is spread across the state in communities of all sizes and types.
- Significant technology advances (tele-work, tele-med, drones, robotics) impact how we work and how services and things are provided.
- On the plus side, technology provides individuals with means and businesses unprecedented access and wider choice of location.
- However, individual AV car ownership is high and dispersed populations are difficult to serve by MaaS or public transit.
- Social equity is a major concern as many seniors and people with lower incomes are "stranded" in place, needing access to affordable housing and transportation to critical services and jobs.

Section Three: Commission Recommendations

Key Challenges

To frame its recommendations, the Commission members laid out what it sees as the key challenges facing transportation in Massachusetts over the next two decades based on the earlier trends analysis and scenario planning:

We can't know the future: Many futures are possible for Massachusetts and its transportation system, depending on how technology develops and is adopted; how population and employment trends evolve; how municipalities shape land use and development patterns; and whether the Commonwealth aggressively tackles transportation greenhouse gas emissions and adaptation to a changing climate.

Disruptive technological change is inevitable: Technology is rapidly changing how, why, and where people and goods move. Electrified autonomous vehicles and other new transportation technologies have the potential to improve safety, speed and efficiency; expand mobility options; and reduce greenhouse gas emissions – if they are harnessed properly and managed prudently.

Massachusetts is growing and aging: After decades of little or no growth, the Commonwealth is projected to have significantly more people, homes, and jobs by 2040: approximately 600,000 new residents between now and 2040 - roughly the equivalent of adding another City of Boston to Massachusetts. Our population is also aging: projections show the proportion of residents 65 and older increasing by 2040. Both of these trends pose real challenges for an already over-extended, largely inflexible transportation system.

The existing transportation system is made up of transportation haves and have-nots: Today's transportation system, not just in Massachusetts but nationwide, is inequitable. Those who do not or cannot own or drive a car – due to youth or age, physical or developmental disability, or financial realities – spend more time and money commuting and sometimes simply cannot get where they need to go, especially in rural and low-density areas.

Transportation needs vary across the Commonwealth and its communities: Massachusetts is a geographically diverse state, and transportation challenges and solutions vary within and among regions.

The transportation system needs to move more people in fewer vehicles: In Massachusetts and throughout the country, the vast majority of trips are made in personal vehicles in which the driver is the only occupant. The transportation system would operate more efficiently and effectively with increased availability and utilization of public transit and an increase in the number of other vehicles that carry more than one passenger, whether they are personal vehicles, private shuttles, or TNCs.

Land use and development decisions drive transportation patterns: Land use, transportation, and economic development are inextricably linked. How much people travel, where they go, and how long those trips are depend on where they live, work, and visit. Those land use patterns, in

turn, are determined by where housing and commercial developers and employers choose to locate and how cities and towns choose to regulate land use and development. Because many of the problems of the Commonwealth's transportation system are not driven by transportation-based decisions but instead by land use and development patterns, those issues need to be addressed as part of solving Massachusetts' current and future transportation challenges.

The transportation system needs to be de-carbonized: In Massachusetts the transportation sector is both the largest and the fastest growing emitter of GHGs. If the Commonwealth is to meet its goal of reducing overall GHG emissions 80 percent by 2050, a large proportion of the emission reductions will have to come from transportation. And while accelerating conversion of cars and light duty trucks to electricity or other zero emission technologies is a key strategy, it is not enough by itself.

Transportation infrastructure needs to be made resilient to a changing climate: New infrastructure must be sited and designed with the climate of the future firmly in mind; existing infrastructure will need to be systematically retrofitted over time to withstand sea level rise, more frequent and violent precipitation, and hotter summers.

Needed investments need to be prioritized and paid for: Maintaining and modernizing the Commonwealth's existing transportation systems while also preparing them for the future will be a challenging, long-term, and expensive process. The Commission could not and did not put a price-tag on its recommendations and is well aware that all of the proposed changes cannot be made at once. The Commonwealth will need to set priorities for maintaining, modernizing, and expanding its transportation systems and will need to leverage a combination of public and private resources to make the investments needed to create, operate and maintain a 21st century transportation system.

Recognizing the Impact on Low-Income Populations and Communities of Color

While it is the Commission's hope that advancements in technology and strategic and thoughtful planning around the future of transportation will improve the quality of life of all residents in the Commonwealth, it was important to the Commission to think about the impact that its recommendations would have on people with low-incomes, disabilities, limited access to public transit and other transportation options, as well as communities of color.

These individuals, families, and communities are disproportionately affected by many of the challenges currently facing our transportation system and related systemic issues, such as pollution, congestion, long commute times, rising housing costs, and unreliable public transportation.

In the recommendations that follow, the Commission has tried to point out the possible implications to these populations, noting instances where a particular recommendation could cause a community to bear a disproportionate burden, and other instances where a recommendation would benefit disadvantaged populations.

The Commission believes it is important for decision-makers to consider the impact of their choices when they shape and implement transportation policy. To help guide decision-makers, the Commission suggests that the best way to learn about the impact of decisions on disadvantaged

communities is to invite them to have a seat at the table. We need greater representation from these communities to help shape decisions around investments, policies, and service delivery and not simply assume that advancements in technology will improve social equity issues in the transportation without smart and proactive public policy interventions. By thinking critically about the impact of our decisions and inviting disadvantaged populations to help shape those decisions, the state is better positioned to see real benefits for those with limited transportation options.

Five Thematic Categories; 18 Recommendations

Grouped into five thematic categories, the Commission has made 18 recommendations for how to best prepare Massachusetts' transportation network for the challenges and opportunities of 2040. Each recommendation consists of a comprehensive recommendation providing longer-term guidance with an eye to 2040, why this recommendation is important, and some initial next steps. The first 16 recommendations do not include consideration of necessary resources, but the Commission provides such input on governance and resources in the last two.

The five thematic categories are:

1. Modernize existing state and municipal transit and transportation assets to more effectively and sustainably move more people throughout a growing Commonwealth;
2. Create a 21st century "mobility infrastructure" that will prepare the Commonwealth and its municipalities to capitalize on emerging changes in transportation technology and behavior;
3. Substantially reduce greenhouse gas emissions from the transportation sector in order to meet the Commonwealth's Global Warming Solutions Act (GWSA) commitments, while also accelerating efforts to make transportation infrastructure resilient to a changing climate;
4. Coordinate and modernize land use, economic development, housing, and transportation policies and investment in order to support resilient and dynamic regions and communities throughout the Commonwealth; and
5. Make changes to current transportation governance and financial structures in order to better position Massachusetts for the transportation system that it needs in the next years and decades.

Given time constraints, the focus of the Commission was on the movement of people, but the Commission recognizes there are other transportation considerations that must be addressed in order to best prepare Massachusetts for 2040. This includes air travel, marine travel, and freight, the volume of which is expected to double in the timeframe of this report.

I. Modernize existing state and municipal transit and transportation assets to more effectively and sustainably move more people throughout a growing Commonwealth

Although it is likely that the network will operate and be used differently in the future, one clear finding of the Commission's work is that transportation in 2040 will still happen on the roads, bridges, sidewalks, and other infrastructure that will be roughly the same as it is today. Improving the mobility of people and goods will require new ideas about how this infrastructure gets used, including ensuring that roadway space is provided for all kinds of travel needs, preferences, and options.

As a result, the mission and perspective of Massachusetts' transportation agencies needs to be redefined to respond to the needs of *people* rather than the needs of *vehicles*. While accommodating the various modes by which people want or need to travel remains critical, reorienting the investments the transportation agencies make and the services they provide towards moving people instead of vehicles is not only a new way of understanding and responding to the challenges we face today, but well-prepares us for any number of possible futures.

Investing in and expanding public transit service is critical. Transit is not only the backbone of the Commonwealth's economic center, it is a lifeline for those who depend on it. It is essential that the Commonwealth builds upon what it has in order to develop a transit network that is as robust, reliable, and convenient to remain a viable option and choice for a greater number of people. It will also be important to expand mobility options in low-density areas.

The Commission asserts that the best approach to addressing these challenges is not by significantly expanding the footprint of Massachusetts' transportation assets, due to both cost and land constraints, but by increasing the person throughput of the state's existing infrastructure. We can accomplish this through a combination of measures that include investing in both public transit and roadways.

Congestion in the transportation system is an important mobility challenge facing the Commonwealth, and it has ramifications throughout non-transportation areas of society. The negative impacts of congestion are numerous, including impacts on employee productivity, GHG emissions, and public health. As the Commission has examined the issue of congestion, it has determined that Massachusetts needs a menu of approaches to help address current and future congestion levels, and there is no quick fix. Governor Baker has directed MassDOT to conduct a study of congestion in the Commonwealth, including examining its underlying causes. The Commission believes that this information will provide a foundation from which to identify potential solutions.

For more information, [please see Volume II](#).

1. Prioritize investment in public transit as the foundation for a robust, reliable, clean, and efficient transportation system.

After months of reading, listening, discussing, and debating, the members of the Commission elected to lead with this first, foundational recommendation because high-frequency, high-capacity public transit is the most efficient and sustainable way to move large numbers of people as they go about their daily lives. This is true today and will be true in 2040 even in the scenario that the transportation system is dominated by fleets of electrified autonomous vehicles. Well-performing, high-capacity public transit will continue to remain important because it is unrivaled in its ability to transport large numbers of people along key corridors at high speeds. Current transit systems, however, will need dramatic modernization and improvement of their physical assets, their organizational and operational capacity, and service models to compete with new, low-cost private sector options. Much of what follows in this report is directed to achieving a public transit system that has, by 2040, become so consistently reliable, efficient, and robust that it can effectively compete with other modes to attract a significantly greater number of riders than the state's transit systems do today. Only by attracting and retaining new riders can the Commonwealth see the benefits that transit can provide for GHG reduction, congestion relief, economic growth, and community revitalization.

The Commonwealth must continue to focus on modernizing its existing public transit assets, including vehicles, to prepare the current system to perform better long before 2040.

Decades of underinvestment have left almost all elements of the MBTA in substandard condition, and RTAs also lack modern assets and systems. The targeted focus that the MBTA's Fiscal and Management Control Board (FMCB) has brought to bear on asset condition and quality is noteworthy. This work must continue, if not accelerate. Moreover, appropriate resources and rigor must be applied to the RTAs.

The public transit agencies of Massachusetts need to reinvent transit operations to offer better, more responsive, and more customer-focused service. Today, transit ridership in Massachusetts and in most major cities across the United States is declining as asset condition and service quality erode and new travel modes offer faster, easier, more convenient, and low-cost personal transportation. This reality could either present a crisis for transit or open up new ways of thinking about how transit should be provided. The Commission's vision is that by 2040, the Commonwealth's public transit should function differently and better than it does now. Future public transit in Massachusetts, whether provided by the MBTA or RTAs, has to be frequent, reliable, and convenient enough to compete in a 2040 world that includes a mix of autonomous vehicles, conventional vehicles, micro-mobility options, and different forms of MaaS. Bus service, in particular, needs to be reinvented – the future can and must be more than 40-foot buses following fixed routes and schedules and mired in the same traffic as personal vehicles. MBTA commuter rail should also be re-visioned, as discussed in Recommendation 15.

Future public transit services will need to operate seamlessly and in concert with new providers offering many kinds of mobility services using ever-evolving technology. By 2040, all of the Commonwealth's public transit agencies should be part of a new interlocking mobility landscape that includes a multitude of actors, some public, some private, some fixed-route, some scheduled, some on-demand – all of which are enabled by technology and seamlessly integrated in the interests of attracting and keeping riders. Customers will have many different ways of consuming transportation and the choice of many shared modes (see Recommendation 7), enabled

by real-time information and made more convenient by common payment platforms that will be the successor to the MBTA's forthcoming Automated Fare Collection 2.0 (AFC 2.0) system.

Why is this Recommendation Important?

- Public transit will remain the important tool to address congestion, even if fleets of electrified, autonomous vehicles are available in key corridors.
- Public transit supports economic growth, stronger property values, and job creation in positive times, and more stability in times of economic weakness.
- For the environment, public transit can reduce pollution and is key to meeting the Commonwealth's GHG reduction and related climate goals.
- For those without access to private vehicles, public transit is critical to get to work and go about the daily round.

Some Initial Steps

1. The Governor should accelerate the reinvention of traditional bus service by convening Bus Prioritization Partnerships led by MassDOT/MBTA, the RTAs, and the Metropolitan Planning Organizations (MPOs), in conjunction with the Commonwealth's municipalities. These partnerships should work to enable bus improvements that prioritize street space for transit, provide signal priority, allow fares to be collected before boarding, and improve real-time information as well as other amenities for bus riders. Transit providers and partnerships should experiment with mixed scheduled and on-demand services that allow buses to better serve lower ridership, lower density corridors. Transit agencies should prioritize investments in cities and towns that allocate space on local streets for high-ridership bus routes.
2. The MBTA should use its AFC 2.0 system, scheduled to come online in 2021, as a common payment platform for as many RTA and private mobility services as possible. Payment automation will allow for more adaptive, responsive fare structures and its transformative potential should be fully leveraged.
3. The MBTA and RTAs should closely collaborate with mobility providers of all types, both public and private, with the goal of creating integrated, cost-effective, door-to-door journeys for riders. Rather than viewing new mobility options as a competitor that may attract riders away from public transit services, they should be seen as a potential partner in closing stubborn first/last mile gaps and providing service in areas that lack the necessary density to support high-capacity transit.

2. Transform roadways and travel corridors to move more people and support changing travel modes and technologies.

While the Commission's first recommendation focuses on public transit as a foundation for the Commonwealth's 2040 transportation system, this second recommendation highlights a complementary set of assets that are similarly foundational: the state-owned and municipal-owned roads and bridges, sidewalks and bike lanes, multi-use paths, and trails that will continue to support travel in 2040. While there will likely be new technologies to provide mobility in the future, many of them will have wheels or tires and travel on corridors that exist today. These corridors, or "rights of way," will increasingly need to serve as shared assets for personal vehicles, transit, freight, TNCs, active transportation modes such as walking and biking, and micro-mobility devices such as scooters. Given that today's roadways and travel corridors are difficult to expand with right-of-way constraints, it is vital that they be re-purposed to support a truly multi-modal transportation future. How public transit in the Commission's first recommendation and the roadways and corridors in this recommendation connect and work together are two essential parts of the transportation system's backbone. The third is described in Recommendation 15 where the re-visioning of the commuter rail system is described.

As today's roadways and travel corridors are maintained and modernized, MassDOT, municipalities, and other owners of roadway and travel infrastructure should update and redesign them to accommodate mobility of all kinds. Transportation service and technology innovations will happen on top of existing, constrained infrastructure. As mobility is changing, transportation corridors will need to change along with it. The Commonwealth and its municipalities own and operate hundreds of thousands of miles of transportation corridors, including roads, sidewalks, bicycle lanes, and off-road facilities. Most of these corridors have functioned in the same way for many decades, with the majority of space dedicated to automobiles and minimal or no space set aside for pedestrians, bicyclists, public transit riders, and others. This traditional way of thinking does not encourage those other ways of traveling and can inhibit them if people feel uncomfortable or unsafe. While attitudes and roadway design methods are evolving with the growing acceptance of "Complete Streets" (a concept that informs a MassDOT technical assistance and funding program that encourages municipalities to plan, design and implement its roadways, sidewalks, and other assets to account for a 'complete' set of modes and public transit connections) the pace of change is slow, and stakeholders frequently argue over inches and feet of pavement. Modernizing and redesigning roadways and travel corridors can help support less congested vehicle travel as well as better road-based transit (see Recommendation 1), sharing of multi-passenger trips in vehicles (see Recommendation 7), and active transportation such as walking and biking (see Recommendation 13).

State and municipal roadway design and operation should prioritize person throughput, rather than vehicle throughput, so that limited corridor capacity is allocated to moving as many people as possible. Transportation agencies too often prioritize the movement of vehicles over the mobility of the people. Going forward, roadway owners must prioritize the movement of the maximum number of people, regardless of mode, in the design of transportation projects both for new facilities and the retrofitting of existing corridors in order to accommodate additional modes. In some cases, this will mean allocating travel lanes and/or curb space for transit and other multi-passenger vehicles. Transportation corridors are a limited resource, and the Commonwealth has a responsibility to ensure that they are well-maintained, used as fully and fairly as possible, and further the achievement of other goals such as reduced congestion, reduced greenhouse gas emissions, and shorter commutes.

The Commonwealth should provide travelers with a continuous, seamless transportation network that allows people using all different modes to travel safely across municipal boundaries and on infrastructure owned by different entities. Ownership and jurisdictional boundaries impede the establishment of multi-modal corridors by producing a patchwork of different designs and facilities. This needs to change. Transportation corridors are owned by the Commonwealth and/or one or more of its 351 municipalities. This produces gaps and missing links in the multi-modal network: a cycle track ends at a municipal boundary, a bridge does not carry through a dedicated bus lane that exists on either side, or a key intersection lacks crosswalks because it is owned by a different entity than the sidewalks surrounding it. These and many similar situations contribute to a transportation environment that discourages multi-modal mobility and promotes vehicular congestion and GHG emissions. MassDOT alone cannot solve this problem, but by 2040 the Commonwealth and its regions and municipalities must be able to provide the users of Massachusetts with a continuous, seamless transportation network that allows people using all different modes to travel safely across municipal boundaries and on infrastructure owned by different entities. Facility ownership and management is irrelevant to the user; safe, comfortable, sustainable mobility on well-maintained facilities is paramount.

Why is this Recommendation Important?

- The Commonwealth owns a finite number of transportation corridors, most of which are in use but some of which are underused or abandoned. Use of these corridors is contested and competed over between users of different modes, between advocates for different means of mobility, and between different visions of what Massachusetts should be.
- In Massachusetts as in many other places, vehicular capacity and mobility have been prioritized over other modes for many decades. The Commonwealth must shift the priority to the mobility of people.
- Recently, facilities for pedestrians and bicyclists have become standard components of MassDOT roadway projects and the projects of some municipalities, but the size and quality of the facilities remain inconsistent and many older roads lack appropriate facilities for walkers and cyclists. Data suggests that many more people would consider walking and biking for short trips if they felt safe and comfortable doing so.
- Recent entrants into the mobility marketplace, including electric scooters and some types of bicycles, have challenged the current thinking about how priority on transportation corridors should be allocated among modes.

Some Initial Steps

1. MassDOT and other state agencies, including MPOs, should require the projects they fund and oversee be designed in ways that maximize multi-modalism and prioritize person throughput over vehicle throughput. MassDOT should update its design standards, policies, and traffic impact analysis guidance to reflect these principles.
2. MassDOT should build on its recent Complete Streets program and develop an action plan in partnership with municipalities to reshape municipally-owned roadways in order to maximize bus and other public transit use, shared rides, walking, and bicycling.
3. MassDOT should establish the policy and statutory framework needed to safely accommodate micro-mobility devices (such as scooters) on state and local roads, sidewalks and multi-use paths. Transportation corridors have traditionally been segmented by mode, and the standard roadway paradigm – road and sidewalk, sometimes on-street parking, an occasional bicycle facility – has been consistent for many decades. But new forms of transportation are challenging that framework. The state should identify key transportation corridors for near-term to be redesigned for low- and medium-speed micro-mobility

devices and bicycles and encourage municipalities to do the same. The separation of users by speed and other comfort/safety measures can create a logical framework within which new modes can more easily be integrated into the transportation system.

3. Work with multiple stakeholders to better manage today's traffic congestion – and the congestion challenges of the future.

MassDOT should take the lead in convening key stakeholders, including other state agencies, employers, municipalities, local/regional planning organizations, and mobility service providers to tackle the challenges of congestion. Transportation congestion is one of the greatest impediments to our economy and is a hindrance to quality of life. Congestion has grown to a nearly intolerable level in the Boston metro region and is increasingly an issue in other urban areas. With the anticipated growth in population and jobs, it is likely that congestion will only get worse without action. But there is no silver bullet – congestion is a product of many factors, and there is no single solution that will alleviate it. In order to be thorough and equitable, stakeholders that represent the perspectives of different travelers in different modes with different needs should participate in developing a multi-pronged approach to better managing traffic flows. While the full set of factors that will contribute to congestion in 2040 is unknown, a comprehensive array of options to address today's congestion can prepare the Commonwealth for the future. The Commission was motivated to provide long-term solutions based on its 2040 mandate. However, the Commission also recognizes that near-term changes are necessary.

While congestion can be indicative of a strong and growing economy, it is abundantly clear that immediate steps are necessary today to alleviate the chronic congestion faced by many, so that congestion does not start to choke the economy. Such steps should be guided by objective data to drive change to the state's current trajectory. The Commission's hope is that the Commonwealth explicitly makes alleviating congestion a priority, and that immediate steps are also considered. As laid out below, one such step is a market signal for drivers on congested routes to face some form of congestion pricing. The Commission does not endorse any one option or form, but recognizes the importance of changing the status quo.

The Commonwealth should prioritize and target investments in public transit and other high-capacity transportation modes to make them more efficient, attractive, and reliable to reduce single occupancy vehicle (SOV) use, particularly on our most congested roads in the urban core. As noted, an important next step for MassDOT and other key actors – the Commonwealth, municipalities, employers, and TNCs – is to prioritize the efficient movement of people and goods. The Commission acknowledges that the maintenance, upkeep, and modernization of transportation is critical, and it urges investment in these assets throughout this report. However, the Commonwealth needs to have more than reliable assets in order to have a transportation system that focuses on efficient throughput. Moving from an asset focus to a person-throughput focus is a subtle but crucial change that prioritizes good infrastructure while properly characterizing the transportation network as a means, not an end.

Why is this Recommendation Important?

- One clear finding of the Commission's research and scenario development is that transportation in 2040 will largely take place on the roads, bridges, airports, sidewalks, and other infrastructure that exist today. Even with some important additions to the infrastructure and technological advances in transportation, much of our infrastructure is likely to look remarkably similar in 2040. This means the role of transportation agencies will need to be more broadly construed as noted above and encompass changing the traveling public's behavior to use these assets differently.
- With respect to the highway system in particular, the Commission expects that keeping congestion at reasonable levels will rely more on efforts to manage the demand for existing

capacity rather than increasing its supply. While selective highway improvements will be necessary, the era of major highway construction is long gone. Congestion mitigation and better transit must go hand-in-hand because neither building capacity nor managing congestion by itself will work. (London is an example. Even with its congestion charge, congestion has returned, but the congestion charge has allowed the city to make significant investments in transit to increase the capacity of the overall transit system).

- It is unclear whether technological advances in transportation will create a future net increase in congestion. On one hand, these advances will help to create more effective use of existing roadways because automation will allow vehicles to travel closer together safely and at higher speeds, and ride-sharing could become more attractive. On the other hand, future trends will dramatically reduce the cost of owning, operating, and even parking a vehicle. These cost reductions could make single-occupancy travel even more attractive. Coupled with widespread adoption of TNCs and MaaS, the Commonwealth could see a larger increase in single-occupancy travel.

Some Initial Steps

1. MassDOT should build on the congestion study currently underway (expected to be complete in Spring 2019) and best practices used elsewhere to understand current congestion levels, and should create a menu of the most feasible options for addressing congestion in specific locations and circumstances. MassDOT should quantify existing congestion levels to provide a baseline from which to measure progress and develop a data platform for options and evaluation. MassDOT should work with local municipalities and MPOs to evaluate traffic flow, roadway capacity, parking management, public transit, and other mobility opportunities to develop a full plate of options to improve specific congestion areas. Finally, but perhaps most importantly, it is critical that the actions regarding public transit be prioritized. The Commonwealth should improve its transit systems while exploring additional options, some of which could include pricing changes.
2. MassDOT should also analyze MaaS/TNC ridership to find where and when it causes the most congestion and what incentives could alleviate it. An early action item could focus on areas in downtown Boston, Cambridge, the Seaport, and the airport, where there are good transit options, high externalities from TNC congestion, and high incomes amongst riders.
3. The Commonwealth, through MassDOT, should engage multiple actors in developing other congestion strategies. Employers, including the state itself, should pursue actions that reduce the number of employees traveling on the roadways at key commuting times. With the support of the MPOs, MassDOT, EEA, and the Executive Office of Housing and Economic Development (HED), municipalities should look at options for action now in their communities and should also consider a regional approach to addressing transportation challenges. TNCs and other mobility service organizations should work with MassDOT to establish programs and policies to materially increase the number of multi-rider trips, especially during peak commute hours.
4. As part of these options, MassDOT should consider various congestion pricing strategies that compel changes in default transportation behaviors on corridors that are or could be served by transit and/or new mobility options. In order to provide an economic market signal, MassDOT should consider and pilot congestion-pricing strategies. Price signals can change travel behavior to alleviate congestion, but only if drivers can change their time of travel or switch to transit or other multi-passenger modes. Pilots should therefore focus on corridors where commuters have alternatives and/or off-peak capacity exists. How the burden of congestion fees may fall more heavily on people with lower incomes should be a specific consideration.

II. Create a 21st century “mobility infrastructure” that will prepare the Commonwealth and its municipalities to capitalize on emerging changes in transportation technology and behavior

Although the Commission expects that transportation in the future will continue to use existing infrastructure, the Commission also recognizes that it could only begin to understand newly emerging modes and what their infrastructure needs will be. Massachusetts can and should ensure that new transportation technologies and the changes in travel behavior associated with them are both supported and managed in order to advance the goals of the Commonwealth.

Single-occupancy and personally-owned vehicles are likely to be a critical part of how people get around for the foreseeable future. However, as discussed, moving towards a transportation system that focuses on people rather than on vehicles or assets is a paradigm shift that can help to meet multiple goals at once: improving social equity and access to opportunities, reducing GHG emissions, and mitigating traffic congestion.

The future of transportation will require an adequate telecommunication network, a robust electric grid, and facilities to charge electric cars. The last is particularly important to advance the electrification of the transportation system, and the Commonwealth needs to ensure that charging sites are equipped to handle the EV growth potential and that the state is prepared for whatever advancements in technology may come.

For more information, [please see Volume II](#).

4. Establish a Commonwealth Transportation Technology Transformation Initiative (T3I) to promote solutions to our most complicated transportation issues and build upon our reputation in transportation innovation and technology.

The Governor should establish the Commonwealth Transportation Technology Transformation Initiative (T3I) to partner public and private resources with innovators to address local transportation challenges. With public and private involvement and investment, the T3I would offer seed and venture capital funding and regulatory support to promote groundbreaking transportation solutions that would directly address the Commonwealth's transportation efficiencies. It could offer competition for remedies to specific operational or capital obstacles. The T3I would support local companies, local jobs, and the local innovation ecosystem. It would tackle some of our most pressing transportation problems, such as how to increase ride-sharing, integrate travel options, ticketing and payment, and innovate on first/last mile challenges by fostering cross-sector collaboration. These and other challenges play to Massachusetts' strengths in technology, artificial intelligence (AI), robotics, cyber-security, and relevant basic sciences.

We are at the early stages of a transportation revolution as profound as any to date. Automation, electrification, and the potential of universal on-demand mobility could be as significant as the development of the great engines, tracks, and infrastructure in the 1800s that moved across the nation, as well as around our cities and nearby communities. It could be as profound and fast as the change from the horse and buggy to the automobile in the early 1900s. It may have societal applications as broad as the rise of the airplane in the first World Wars to its game-changing role in commercial travel. Where people live and work has been largely determined by the infrastructure and services from these previous technology revolutions.

The Commonwealth needs to harness the expertise of its talented workforce, academia, entrepreneurs, and innovators to take full advantage of the opportunity this revolution presents. To be clear, the intent of this investment is to leverage private resources to solve some of Massachusetts' intractable transportation problems by fostering collaboration through targeted public investments. Recognizing that the Commission is suggesting investment of precious taxpayer dollars at a time when the needs are greater than the funds available, the Commission suggests that policy makers analyze existing models here and in other jurisdictions to understand how to best create this effort, explore funding sources for this investment, develop clear goals of what the investments are trying to achieve, establish criteria for receiving the funds, and limit the T3I to one-ten year period. The goal is to create a powerful virtual cycle of investment in transportation technologies in order to address rapidly emerging new problems while affirming its place in our economy.

Why is this Recommendation Important?

- The Commission is interested in focusing the strengths of the state's economy and labor force on solving common transportation opportunities and challenges in the Commonwealth. Massachusetts has historically been on the cutting edge of shaping major technologies for the world (e.g., artificial intelligence, computer science, biotechnology, life sciences). As home to several renowned higher education institutions and non-profit, defense, and company-based research institutions, the Commonwealth is uniquely positioned to leverage our existing assets and competencies to become one of the premier places in the world for the transportation technology transformation.

- The Commission envisions an effort that institutionally supports initiatives that revolutionize the mobility marketplace and transform domineering transportation paradigms, capitalized by both public and private sources. The T3I could potentially be folded into an existing quasi-public economic development agency. Through this process, the Commonwealth can bring together the brightest minds to solve its toughest transportation-related problems and use this expertise to enable the transportation economy and create more jobs. This recommendation is intended to be both aspirational in terms of establishing the state as a leader in the transportation transformation, as well as to provide a practical platform of support, technical assistance and innovation.
- While the Commission's charge is to make recommendations to the Commonwealth, the Commission realizes that the strength of Massachusetts is the unrivaled minds of its population. Harnessing those minds – inside and outside of government – is critical to addressing the myriad challenges impacting each and every resident. The T3I, in concert with our other recommendations, offers a broad-based approach to recognize and build on the scale and depth of our public and private sectors to literally move the world.

Some Initial Steps

1. The Commonwealth should engage private and philanthropic sectors and commit some public money to fund a number of research and technology awards, possibly called the Mass X Prizes, to fund advancements in technology and system designs that address current or anticipated transportation challenges and opportunities like shared rides and first/last mile connections.
2. The Governor should explore the development of T3I. We suggest that a public-private team, including Massachusetts universities, be brought together to learn how these kinds of technology transfer initiatives have worked both in the state and in other jurisdictions, determine appropriate organizational frameworks, and investigate various funding opportunities and allocations from the federal and state government along with the private sector.

5. Support and accelerate efforts to consume transportation differently.

MassDOT should centralize knowledge and lead the development of policies related to changes in mobility practices, including ride-sharing, vehicle-sharing, Mobility as a Service (MaaS), on-demand mobility (ODM), and micro-mobility. The Commonwealth should be a place that welcomes, encourages, and deploys new modes of mobility. Establishing expertise in new travel options and the technologies that enable them not only sends a message that attracts developers and encourages innovation in the Commonwealth, but prepares both policy-makers and residents for changes in broader transportation and mobility paradigms. MassDOT should explore policies that support multi-passenger trips, encourage public transit agencies and other service providers to experiment with MaaS platforms, and work with municipalities in areas where access to new mobility services and technologies are limited. MassDOT, MPOs, and municipalities should also work directly with new mobility service providers to minimize “deadhead miles” (meaning the distance a shared vehicle has a single occupant – the driver) and disruptions to traffic flows.

The Commonwealth should continue to be an innovation proving ground for shared mobility initiatives. As the home of Zipcar, Massachusetts has a strong history in leading on new mobility business models. The growth of MaaS and other shared multi-modal options that can support car-lite or car-free lifestyles presents an opportunity to meet several goals of the Commission. Establishing the Commonwealth as a capital for shared mobility services and technologies builds on the state’s strengths as a global center of research, technology, and innovation. This involves not only the actions described above, but the resource investment and support of a variety of stakeholders including other state agencies, universities, research centers, and industry leaders.

Why is this Recommendation Important?

- MaaS relates to many of the concerns over the impact of the transportation network both now and in the future, including reliance on single-occupancy vehicles (SOVs), transportation-sector GHG emissions, and congestion. As MaaS continues to evolve, the Commonwealth must ensure that shared mobility and on-demand services are leveraged as an opportunity to respond to challenges of traditional public transportation systems, including first/last mile connections and providing services in low-density areas.
- Although introduced to the transportation marketplace fairly recently, adoption of MaaS has been rapid. On-demand mobility (ODM) and shared mobility services are fairly mainstream among certain groups of residents in certain geographies, and the number of on demand mobility services available to residents is growing rapidly. These include, but are not limited to, ride-hailing, ride-sharing, carpooling, car-sharing, bike-sharing, and scooter-sharing.
- Personally-owned vehicles will continue to be a critical part of how people get around in the future and the Commission acknowledges that they will often be single-occupancy. However, the Commission recognizes that the confluence of multiple advances in technologies and changing transportation preferences and behaviors means that there is an opportunity to advance new mobility paradigms that prioritize the movement of people over the movement of vehicles.

Some Initial Steps

1. MassDOT should take the lead on issues related to shared mobility and other transportation service innovations. MassDOT should also explore protocols and policies that improve and enhance shared mobility options, collaborate with municipal and regional land use agencies to address shared vehicles and trips at the local level, and develop a strategy to establish Massachusetts as a capital of shared mobility services and technologies.

6. Enable and promote a statewide telecommunications infrastructure to support the availability of real-time transportation information and deployment of connected and autonomous vehicles.

The Commonwealth should promote full statewide communications infrastructure (5G, Wi-Fi, and their future counterparts) that can support and enable new technologies and services, from connected and autonomous vehicles (C/AVs), to real-time traffic and asset management systems, to telecommuting opportunities. Telecommunications are already essential to the functioning of our transportation systems. They are presently used in applications for navigation (GPS), public transit operations, and TNC businesses and new technologies will likely increase people's reliance on the telecommunications network. The Commonwealth will need to take affirmative steps to ensure that all regions of the state are provided access to high-quality data communications systems that enable all residents the opportunity to take advantage of these new transportation technologies. As with other types of utility telecommunications services, it is expected that the private sector and some municipally-owned utilities will take the lead; however, in instances where that is not financially feasible, the Commonwealth must be prepared to provide financial support so that C/AVs can travel efficiently throughout the state.

Since the siting of infrastructure to support new technologies includes municipal approval, MassDOT and other state agencies will need to expedite their review and approval processes while better coordinating them with local communities. Establishing a more equitable and effective system with the private sector for siting and constructing communications infrastructure will help the Commonwealth better support existing and new transportation services including C/AVs, TNCs, MaaS platforms, bike-sharing, scooters, and any other future modes of transportation.

Why is this Recommendation Important?

- The lack of high-speed internet access in many communities in the state – especially Western Massachusetts – is a challenge for public transit agencies, other mobility providers, and residents who would like to use these services. The dynamic of uneven access to telecommunications creates a fractured transportation landscape in the state and establishes boundaries between different areas in terms of how much mobility is enabled both within and between them.
- New mobility services and transportation information technologies like autonomous vehicles, Waze, and TNCs tend to rely on telecommunications networks, including 5G and WiFi – a trend that is expected to increase over time. In order to support widespread adoption of these and other modes that will be available in the future, the state should ensure that a robust network is available, reliable, and prepared for increased use.
- Recent experiences with cell phone and broadband technologies have also shown that low-density rural areas are frequently left behind in terms of the availability of new technologies that rely on a reliable communications network.

Some Initial Steps

1. The Governor should convene a task force with representatives across state agencies, municipalities, regional land use and planning organizations, private sector telecommunications providers, new mobility services, and other stakeholders to understand what resources and infrastructure are needed to strengthen, better connect, and prepare the state's communications network for changes in use and demand.
2. The Governor should convene an oversight body that evaluates opportunities to use state property as siting locations for the deployment of communications infrastructure.

7. Develop a long-term strategy for supporting connected and autonomous vehicles in Massachusetts.

MassDOT should dedicate resources to the management of an interagency Connected and Autonomous Vehicle (C/AV) Committee, as described in the draft Autonomous Vehicle (AV) Working Group Report, to understand how the Commonwealth can prepare for and maximize the positive impacts of C/AVs. MassDOT should continue working in partnership with other state agencies, municipalities, C/AV companies, and other entities (such as telecommunications networks) involved in the deployment of these vehicles to build the knowledge and infrastructure capacity required to prepare the Commonwealth for the optimal deployment. MassDOT should also continue to develop AV testing protocols, engage with law enforcement and first responders, and plan for new types of vehicles and testing, such as vehicles without a seated driver. As technologies improve, the state should prepare for major growth in the deployment of these vehicles and capabilities, including their integration into the broader transportation infrastructure.

The work of the C/AV Committee should evolve to support the changing needs of appropriate planning and regulatory oversight of emerging C/AV technologies. For example, the C/AV Committee should review highway design and maintenance standards to support C/AVs, including lane marking delineations, signage, lighting, and more. The Committee should assess cybersecurity vulnerabilities, including hacking, data theft, and power or hardware failures and develop a strategy for the deployment of autonomous vehicles for hire in ODM systems, including reviewing existing legislation and regulation of ride-for-hire services, insurance minimums, and third-party liability. The C/AV Committee should also collaborate with the trucking industry to facilitate the use of C/AV technologies in commercial delivery services.

The C/AV Committee should examine equity issues concerning the deployment of C/AVs to provide services beyond the most densely populated and/or affluent areas, and continue the growth and benefits of C/AVs for as many Massachusetts residents as possible. The Committee should ensure that all regions of the state, particularly rural areas and Regional Transit Authorities (RTAs), have access to C/AV initiatives. C/AV technologies and economics are expected to favor urban and suburban conditions for initial deployments since roads in these communities are often in better condition and better-lit, connectivity is stronger and more reliable, and density contributes to economic efficiencies. State approval of C/AV development plans should promote initiatives to serve less dense and economically-disadvantaged environments. The C/AV Committee should monitor advances in C/AV research and other technologies that may be able to provide efficient transit service in lower-density areas and support the efforts of RTAs.

The Governor should consider proposing legislation to establish statutory and regulatory structures that enable the safe and reliable deployment of C/AVs. With respect to connected vehicles, the Commonwealth should develop a clear process for engaging with public and private partners, including the United States Department of Transportation (USDOT), vehicle and device manufacturers, academia, and state and local governments for the development and deployment of CV technologies. With respect to AVs, beyond the testing of these vehicles with a driver, no framework or regulatory structure exists for the testing and operation of emerging AV technologies, as detailed in the final recommendation of the draft AV Working Group Report (released September 12, 2018). Clear regulatory authority and policy guidance should be developed and designed to ensure that the positive benefits of C/AVs are recognized and coordinated with the challenges of these emerging technologies. Legislation should carefully consider the role and authority of

municipalities and local road owners. Such considerations go beyond traditional issues such as licensure, registration, liability, and insurance requirements, which are already under the purview of the Registry of Motor Vehicles (RMV). The creation of a clear and stable regulatory structure can also support Massachusetts' reputation as an innovation hub for C/AV technologies.

Why is this Recommendation Important?

- C/AV technologies, advanced driver assistance systems, and CV technologies have already begun to provide improvements in travel safety, traffic efficiency, and vehicle emissions, among other emerging applications.
- Vehicles will be increasingly connected and automated by 2040, though it is unlikely that all vehicles in the Commonwealth will be fully autonomous or connected by that time. Therefore, managing the transition between partially autonomous and fully self-driving vehicles will be critical.
- Significant data flows between connected vehicles and infrastructure, and vehicle-to-everything (V2X) integration, will provide invaluable insights into the movement of people and goods throughout the Commonwealth and will allow for stakeholders to manage, measure, and improve throughput once baselines have been established.
- A mixed fleet of automated and human drivers will have an uncertain impact on the rate of adoption of autonomous vehicles or the pace at which we realize the potential advantages of AV technology.

Some Initial Steps

1. MassDOT should prioritize the efforts of the C/AV Committee, with an immediate focus on integrating its functions within the participating agencies. The Committee should be tasked with studying the creation of a regulatory body to cover the areas outlined in the recommendation, including what authorities may be required. Existing regulatory bodies, such as the Department of Public Utilities (DPU), RMV, and others should be studied to consider best practices for use under a C/AV regulatory body.
2. With the advice and recommendations of the C/AV Committee, the Governor should file legislation to establish statutory and regulatory structures that enables the safe and reliable deployment of C/AVs.

8. Enable and promote a ubiquitous electric charging (and/or alternative fuel) infrastructure to support the widespread deployment of electric and autonomous vehicles.

The Commonwealth should facilitate a statewide electric charging infrastructure, and/or the infrastructure needed for other alternative fuels that is fast, equitable, robust, and resilient in order to support an increasing fleet of zero emission vehicles (ZEVs). To meet the Commonwealth's emission reduction goals outlined in the Global Warming Solutions Act (GWSA), the Commonwealth needs all types of vehicle owners, including residents, businesses, non-profits and government agencies of all sizes to significantly reduce reliance on fossil fuels. However, only through a robust charging network will consumers have the necessary confidence in reliability for wide-scale EV adoption. One critical element of this network is to ensure charging stations are easily available – not only at homes and workplaces, but in locations that support longer journeys, such as gas stations or at highway rest stops. Stations should be designed to allow easy access by all users, and fleet operations should explore ways to share stations with other users. Regardless of what the charging technology is or evolves to be, the Commonwealth needs basic infrastructure to ensure that sites are accessible and charging stations can be installed easily.

The Commonwealth should develop standards or incentives for vehicle fleets (driven by humans or driverless) to be electric, charge during off-peak hours, and be available to deliver energy back to the grid at peak times. In addition, utilities should be encouraged to establish off-peak pricing programs that give car, bus, and truck owners and operators an incentive to charge their vehicles during off peak hours, and to the extent technically feasible, to sell electricity back into the grid at peak times. Moving forward, the Commonwealth should promote a flexible market structure that encourages innovative charging services as part of a competitive marketplace. Such a market can incent charging providers to compete on price, service, speed, networked capabilities, location, and customer experience.

In addition, the Commonwealth should promote technologies that provide for faster charging. Although most EV owners charge at home or in the workplace, where the car can sit for prolonged periods during charging, the introduction of fast charge infrastructure and the ability of cars to increasingly charge at faster rates has the potential to dramatically change the EV market by making EVs more attractive to consumers. It is also important that all communities, regardless of income, have access to EV charging. Some residents may not have their own parking facilities, so accommodations will be needed to give them reliable access to stations near their homes. The Commonwealth should incentivize siting charging stations in disadvantaged communities and multi-unit dwellings.

Why is this Recommendation Important?

- In 2017, there were 12,000 EVs registered in Massachusetts (out of 2.37 million).
- Sales and manufacturing statistics show a dramatic acceleration of EV market penetration.
- While only a small portion of the existing vehicle fleet is electric, US EV sales grew 26 percent between 2016 and 2017 with even more recent sales data from August of 2018 showing a 120 percent growth rate of year over year sales.
- Numerous analyses show expectations of a majority of new car sales being electric by 2040.
- As of April 2017, nine global original equipment manufacturers (OEMs) and 26 Chinese OEMs have announced plans to produce or significantly expand their EV models over the next ten years. The number of available EV models worldwide is expected to grow 20 percent to 216 models available in this coming year.

- Eversource and National Grid were approved for programs to install charging infrastructure throughout Massachusetts, two of the largest utility initiatives outside of California.
- By focusing on the infrastructure required to support this transition, this recommendation supports the Massachusetts pledge, along with seven other states, to have a combined 3.3 million EVs on the road by 2025.
- Technology is being developed to charge a car at 400kW, which translates into about 250 miles of range in twelve minutes. This faster rate of charge changes the landscape for charging infrastructure in a fundamental way and will increase EV adoption rates.

Some Initial Steps

1. DPU should approve electric utility programs that enable competition, innovation, and customer choice in EV charging. In addition, to direct investment in charging, utilities can use their relationships with customers to make many aspects of vehicle electrification, such as home charging installation, much easier. Just as we have relied upon utility-sponsored programs such as MassSave to deliver energy efficient homes and businesses, so too could utilities help with charging and other services to facilitate electrification. The Commission acknowledges that under current utility rate structures, commercial and industrial users of the electric grid in general pay a higher share of system costs. Thus, it will be important to balance the benefits of ratepayer support for electrification with the costs, particularly on commercial and industrial users. It will also be important to ensure that direct benefits are provided to these classes of customers, as is being done, e.g. through ratepayer-funded energy efficiency programs.
2. The Governor should direct MassDOT, EEA and all other state agencies to expand its ZEV-supporting infrastructure within its facilities, including rest stops, and should encourage RTAs, other authorities, and the state university and college system to do the same.
3. The Governor should convene cities, utilities, TNCs, taxi fleets, transit agencies, truck fleets, charging technology providers, and potentially airports to create shared infrastructure that will provide adequate charging for their respective fleets, visitors, commuters, and those without designated parking space or garages. Further, this effort should explore accommodations for EV charging on streets, existing gas stations, rest stops, and other locations, especially for households with low incomes.
4. The state building code should be updated to require new homes, buildings and parking structures to be “EV ready,” enabling the conduit and wiring in place to accommodate sufficient EV charging for their sizes.

III. Substantially reduce greenhouse gas (GHG) emissions from the transportation sector in order to meet the Commonwealth's Global Warming Solutions Act (GWSA) commitments, while also accelerating efforts to make transportation infrastructure resilient to a changing climate

With the 2008 adoption of the Global Warming Solutions Act (GWSA), Massachusetts became one of the first states to move forward with a comprehensive regulatory program to address climate change. In the ten years since, the challenge to the climate has increased significantly. As reflected by the recent sobering statement from the Intergovernmental Panel on Climate Change (IPCC): “the world is likely to experience devastating impacts from climate change earlier than expected and at lower temperature increases than expected.” To avoid runaway impacts, the IPCC warns that there are approximately 20 years to act to radically decrease net greenhouse gas (GHG) emissions to safer levels.

Furthermore, more recent research suggests that the Northeast United States in particular could bear the brunt of especially harsh climate impacts, including coastal impacts, threatening not only the Commonwealth's infrastructure but sense of place. The Fourth National Climate Assessment of the U.S. Global Change Program notes that “the Northeast's urban centers and their interconnections are regional and national hubs for cultural and economic activity. Major negative impacts on critical infrastructure, urban economies, and nationally significant historic sites are already occurring and will become more common with a changing climate.”

The GWSA required the Executive Office of Energy and Environmental Affairs (EOEEA), in consultation with other state agencies and the public, to set economy-wide GHG emission reduction goals for Massachusetts:

- Reduce emissions by 10 to 25 percent below statewide 1990 GHG emission levels by 2020; and
- Reduce emissions by 80 percent below statewide 1990 GHG emission levels by 2050.

Transportation is both impacted by climate change and contributes to it. The transportation sector accounts for 40 percent of all GHG emissions in Massachusetts, and nearly half of these are from passenger vehicles alone. Addressing the transportation sector's impact on the Commonwealth's ability to meet GHG emission reduction goals is not only prudent, but absolutely necessary.

The electrification of transportation is one way to reduce harmful emissions. Massachusetts has already committed to electrifying all vehicles, “as fast as possible, and no later than 2050,” through the International Zero-Emission Vehicle Alliance. As part of its consideration of electrification, the Commission examined the capacity of the electric grid to meet increased demand from electric vehicles (EVs). The Commission considered other strategies to help cope with transportation-related emissions and climate threats. These include regional, market-based mechanisms to help manage GHG emissions and changes to design and engineering standards to ensure that transportation infrastructure is resilient in the face of extreme weather events.

For more information, [please see Volume II](#).

9. Establish a goal that beginning in 2040, all new cars, light duty trucks, and buses sold in Massachusetts will be electric or use another technology that meets the same emissions standards.

The Governor should establish a goal that new cars, light duty trucks, and buses sold in Massachusetts during or after 2040 to be electric (or use other technology achieving the same emission standard). Achieving the Commonwealth's 2050 GWSA mandate will require the near-complete transition of our vehicle fleet (cars, trucks, and buses) to electric vehicles or other zero-emission vehicle (ZEV) technology. Because vehicle fleets turn over slowly, for vehicles on the road to be electric by 2050, we will need all vehicle sales to be electric by no later than 2040 (perhaps sooner for some vehicle classes). One of the barriers to EV adoption is the lack of consumer choice—currently carmakers are not building a sufficient range of cars that consumers want (e.g., SUV's). While this is not a problem that Massachusetts alone can solve, many countries have embraced a similar goal (UK, France, Denmark, Taiwan, Netherlands, Israel, Ireland, India, Norway, and most recently the province of British Columbia), and states such as California are actively considering it. The history of state leadership on climate change reveals that when one state adopts an important policy, others follow. Embracing the goal of all-electric new sales by 2040 by various levels of government, especially when coupled with concrete steps to achieve that goal, sends a clear signal to the vehicle industry to design, build, and market electric cars, buses, and trucks that consumers want.

A comprehensive approach to the electrification of vehicles is needed that includes increased funding for point-of-sale rebates to help residents with low- and moderate-incomes to purchase an EV, subsidized electric vehicle financing, support for heavy duty electrification, and increased support for grassroots EV consumer marketing and bulk purchasing programs. The amount of these subsidies, and the eligibility requirements, will need to be carefully assessed. Based on available information about declining battery costs (the primary differential between electric car and gasoline powered car costs), the Commission anticipates that these subsidies and incentives will taper off as the cost gap narrows.

Why is this Recommendation Important?

- In Massachusetts, emissions from the electricity sector have fallen 58 percent since 1990, while emissions from the transportation sector are still the same.
- In Massachusetts, annual CO₂ emissions from internal combustion engine (ICE) vehicles (tailpipe emissions) are 3.27 times higher compared to EVs (emissions from electrical power sources).
- Massachusetts' Department of Energy Resources' (DOER) comprehensive energy planning process assumes that two-thirds of new vehicles will be electric by 2030.
- National Grid's study emphasizes the need for new sales to be electric no later than 2028.
- A recent northeast 2050 deep de-carbonization study calls for complete electrification of light duty vehicles by 2050.
- In Massachusetts, because of the relatively clean electric grid, an EV is the equivalent of an ICE car that gets over 100 MPG.

Some Initial Steps

1. MassDOT and EEA should conduct a study of the broad categories of transportation use cases in the Commonwealth and identify the most promising vehicle technologies that could provide a long-term solution within each sector.

2. The Governor should establish a goal that by 2030, all cars, light duty trucks, and buses (as appropriate) purchased with state resources will be ZEVs. Establishing purchasing targets for state agencies, quasi-state entities, and public universities for purchases of electric vehicles that at least account for in-service performance requirements and the lifetime capital and operating costs as compared to conventional vehicles is critical. Consideration should be given to establishing incentives for electric buses and light duty trucks. California's Hybrid and Zero-Emission Truck & Bus Voucher Incentive Program (HVIP), for example, offers \$150,000 off the purchase of an electric bus – which rises to \$165,000 for EV buses in environmental justice communities. These programs are one reason why Los Angeles, San Francisco, and New York City transit agencies have been able to make commitments to move towards an all-electric transit fleet.
3. MassDOT and EEA should explore ways to expand their support for group-purchasing programs similar to Green Energy Consumers Alliance's Drive Green program or the Braintree Drives Electric program. These programs have shown to be successful at reducing upfront costs for consumers, expanding awareness of EV technology, and facilitating EV sales. Further efforts should be considered to make electric vehicles affordable for consumers with low and moderate incomes. These programs may prove critical in making the experience of buying an EV easier for potential consumers.

10. Collaborate with other Northeast and Mid-Atlantic states to establish a regional, market-based program to reduce transportation sector greenhouse gas (GHG) emissions.

The Commonwealth should publicly support the prompt development and implementation of a regional program that uses market mechanisms and public investment as a means to limit GHG emissions from the transportation sector. One form that such a program might take is a cap and invest program for transportation emissions. A cap and invest program for transportation is a significant policy mechanism to tackle one of the largest challenges—lowering emissions from the transportation sector. Under a cap and invest program, the state would join with the other states of the Northeast and mid-Atlantic regions to impose a declining cap on pollution from transportation fuels, require transportation fuel distributors to purchase emission allowances sold in regional auctions from within those limits, and use the funds generated from these allowance sales to invest in clean transportation and other pressing transportation needs. Cap and invest is a policy model with a track record of success in reducing emissions while growing the economy and reducing costs for consumers.

For such a program to be effective and fair, the Commission recommends the following:

1. It should be regional in nature and include a critical mass of northeastern and mid-Atlantic states;
2. The states should conduct a detailed study that identifies both the benefits and costs, assuming a reasonable range of program design scenarios (e.g., different levels and trajectories for a declining cap, different reinvestment of the proceeds); and
3. Massachusetts should accelerate the process of expanding low carbon transportation alternatives (EVs, public transit, active transportation, and others) now, so that these options are available before the costs of cap and invest are passed down to consumers.

It will be critical to ensure that a cap and invest program covering transportation fuels can offer broad benefits to different groups within Massachusetts while not disproportionately burdening commercial users. That means supporting programs all across the state, paying particular attention to the needs of rural communities that have particularly high transportation costs, and supporting increased equity in low-income and environmental justice communities. Developing this program will require regional cooperation through forums such as the Transportation Climate Initiative (TCI), which has been working for years to bring together officials from northeast and mid-Atlantic states representing transportation, energy, and environmental agencies.

The Commission also recommends exploring the adoption of a regional Low Carbon Fuel Standard (LCFS). A regional LCFS is a market-based, technology neutral program that has been successfully adopted in CA, OR, and other jurisdictions. It requires fuel providers to gradually reduce the carbon intensity of fuel over time. They can meet these goals by improving production techniques, blending clean fuels into existing fuels, or purchasing credits generated by clean fuel providers (such as electricity and renewable fuels). The LCFS has proven to be a useful complementary measure to California's cap and trade program in that it drives the production of low carbon fuels, promotes electrification, and also reduces the compliance costs of the program.

Why is this Recommendation Important?

- Under the Regional Greenhouse Gas Initiative (or RGGI), the Northeast is now on track to achieve a 65 percent reduction in regional emissions from electricity by 2030. This has not

come at any cost to the economy; to the contrary, independent, peer-reviewed analysis indicates that the RGGI program has helped grow the economy of RGGI states by \$2.9 billion. The economic benefits are derived from the fact that RGGI states are at the end of the energy pipeline, and therefore fossil fuel electric generation exports consumer dollars from the region. In contrast, investing the RGGI proceeds in energy efficiency and renewable energy generates jobs and multiplier effects within the region, and energy efficiency in particular lowers total energy costs for consumers.

- This same underlying logic applies to a cap and invest program for transportation. A successful cap and invest program will reduce gasoline consumption and the export of dollars to fossil fuel producers. It will expand more efficient and lower carbon forms of transportation, including public transit, electric vehicles, biking and walking, and other options, and this investment should result in job creation within the region and consumer savings. While this theory has a strong underpinning in the documented RGGI experience, a comprehensive economic analysis is needed to determine its validity and inform program design. States should be integrally involved in such an analysis, and as was the case with RGGI, the analysis should include a detailed presentation of benefits and costs including a wide range of design parameters and strategies for investments of the proceeds.
- Quebec and California have both expanded cap and invest to transportation fuels and the result has been billions in funding for clean transportation.
- California is set to spend over \$2 billion from their program on transportation this year. This includes hundreds of millions in clean vehicle incentives that have helped California achieve ZEV sales three times higher than the Northeast; investments in public transportation to ensure greater reliability and improved service in every major California city and dozens of small towns; and investments in affordable housing near transit.
- For example, if the Northeast and mid-Atlantic states were to implement a program with similar allowance auction prices as California (\$15/ton), this would generate approximately \$500 million in new revenue for Massachusetts and cost the average driver \$7 per month. If the allowance prices resembled RGGI prices (\$4.50/ton), this would generate approximately \$150 million for Massachusetts and cost the average driver about \$2 per month.
- It's important to recognize that pricing alone will not be a major driver of changes in behavior in the transportation sector, at least, not at the modest auction prices of a cap and invest program modeled after Quebec and California. It is the investments in clean transportation, combined with the price signal, the overall limit and additional complementary policies that will allow Massachusetts to achieve its climate goals in transportation.

Some Initial Steps

1. The Governor should publicly support a regional program, and work with other states to design the program, including supporting a comprehensive economic analysis of design options.
2. The Secretaries of EEA and MassDOT should convene a stakeholder process to receive input on the design and operation of a regional program.
3. The Governor should direct appropriate agencies to investigate regulations to codify the program and any legislation needed to allocate revenues.

11. Make all current and future critical state and municipal transportation infrastructure resilient to a changing climate.

All publicly-owned or funded transportation infrastructure in Massachusetts, across all agencies, should be the subject of a vulnerability assessment, the outcomes of which can then inform capital planning. Much good work has already been done in this area, but much remains to be done between now and 2040. Using the most current projections for flooding, storms, and intense temperatures, the Commonwealth needs to ensure that all transportation facilities are evaluated for their vulnerability to increasingly severe weather, as well as for their criticality to the transportation network. As needed, MassDOT and other state agencies should assist and support municipalities with this effort. Once complete, this work should be explicitly connected to capital planning efforts at the state, regional, and local levels, so that key resiliency projects are allotted funding and fed into project development processes.

State and local agencies should prioritize resilience in the maintenance and construction of the transportation facilities for which they are responsible. As part of capital planning, transportation agencies select, prioritize, and design projects based on a wide range of criteria, including safety, economic impact, and congestion reduction. To date, resiliency has not been a priority for transportation agencies in Massachusetts, and projects continue to be prioritized and designed without a focus on their long-term viability in a changing climate. This needs to change, so that by 2040 the Commonwealth can be well on its way to having a transportation network that can withstand extreme weather. The urgency of climate impacts is such that MassDOT and other state and municipal transportation agencies need to make resiliency an area of focus for capital planning and construction, and must do so in two ways: (1) prioritize the necessary retrofit and adaptation of critical infrastructure in a responsibly incremental way, and (2) make resiliency a key design feature – on par with safety and mobility – in the engineering and construction of all projects.

To advance this goal, MassDOT should develop and disseminate resiliency-oriented statewide design standards for transportation infrastructure, including infrastructure owned by the MBTA and the RTAs; by 2020, no project should be built that does not conform to those standards. Informed by best practices from elsewhere in the United States and globally, MassDOT should develop design guidelines that address issues of adaptation and resiliency in the Commonwealth. While MassDOT has shifted the paradigm on roadway design in order to make standard the inclusion of facilities for bicyclists and pedestrians. MassDOT must now use its role to establish and institutionalize resiliency-oriented design standards for all transportation infrastructure in the Commonwealth.

Commonwealth funding should only be allocated to projects that are designed to be resilient and meet the design standards laid out by MassDOT. Funding programs like the MassWorks Infrastructure Program, the Infrastructure Investment Incentive Program (I-Cubed), or even locally funded programs like District Improvement Financing (DIF) when used for infrastructure – as well as any similar programs established between now and 2040 – should be limited to investments that meet the MassDOT climate change mitigation and adaptability standards. Both for the transportation projects it builds and for those it funds, the Commonwealth should be disciplined about adhering to engineering guidelines that will protect its investments and infrastructure, long-term, from climate change impacts.

Why is this Recommendation Important?

- Climate change already impacts what we own and what we build. In just the past few years, rapidly shifting environmental conditions and extreme weather are impacting and too often overwhelming transportation infrastructure. This compromises our facilities and causes outages – some for extended periods of time – and generates significant, often unbudgeted, expenses.
- The cost of addressing these impacts as they rise – a constant patch and repair approach – is substantial and will only increase. To protect our investments and maintain mobility before, during, and after a weather event, it is vital that the Commonwealth make its assets as resilient as possible to a climate that it likely to only become more damaging.
- The transportation system has a vital role to play during weather emergencies, providing both a means of evacuation and a way to maintain mobility and basic services in the immediate aftermath of storms. For this reason and many others, the Commonwealth's infrastructure needs to be able to withstand whatever climatic conditions it may face.

Some Initial Steps

1. State agencies that conduct vulnerability assessments should extend their scope to additional state-owned facilities, as well as municipal facilities and important privately owned transportation assets.
2. Working with other entities and asset-owners as helpful and appropriate, all agencies with oversight over transportation infrastructure should initiate a process of developing resiliency-oriented design guidelines.
3. Owners of transportation infrastructure and MPOs should integrate resiliency issues into its project prioritization, capital planning, and project development processes.

12. Ensure that sufficient electric capacity is available to provide reliable, clean, and competitively priced power supplies for all electricity users as electrification of the transportation sector accelerates.

As electric vehicle (EV) penetration accelerates, Massachusetts should work in close coordination with ISO New England (ISO-NE) and other states to ensure that sufficient electricity continues to be available to provide reliable, clean, and competitively priced power supplies for all electricity uses in the Commonwealth. ISO-NE is the independent, not-for-profit entity responsible for operating the region's bulk electric grid. As part of its mandate, ISO-NE is required to ensure that the region complies with the federally approved standards of the North American Electric Reliability Corporation. ISO-NE also develops long-term reliability plans and operates the competitive wholesale electricity market, which provides for the dispatching of power plants and other electricity supply resources on a least-cost basis, consistent with the reliability requirements of the grid. As part of this, ISO New England is tasked with setting resource adequacy - meaning that there is sufficient electric capacity to meet demand - through a Forward Capacity Market, which runs more than three years into the future to signal the opportunity for development of new supply sources and the retirement of existing ones.

Why is this Recommendation Important?

- Some studies show that introducing an EV to a neighborhood is roughly the same as adding another house in terms of energy consumption. In Massachusetts, the electric grid can likely support light-duty vehicle charging, but growth in EV buses and other heavy-duty vehicles may require costly transmission and distribution system upgrades.
- Wholesale competitive markets and state-mandated procurements develop electricity supplies. Today, procurements account for less than 20 percent of the electricity consumed in New England.
- By 2030, with large amounts of new clean energy resources expected to enter the market through authorized procurements, this share is expected to make up over 50 percent of electricity consumption.
- National Grid's 2050 report shows that should we get to a fully-electrified vehicle fleet by 2040, the potential increase in electricity demand would be 17 percent. That level of change is not unusual in the electricity industry, and such an increase over that period is still below the one percent annual demand increase that occurred for the bulk of the 20th Century.

Some Initial Steps

1. The Governor should convene a meeting with the other New England states to task ISO-NE to study electricity demand trends between 2030 and 2040, with a particular focus on EV growth across the region.
2. The Governor should direct EEA and its various departments and with the Department of Public Utilities (DPU) to examine regulatory and rate structures for EV charging. EEA should also study emissions implications of large-scale EV penetration with current electricity supply mix, the projected mix in 2030, and the projected mix in 2040.

IV. Coordinate and modernize land use, economic development, housing, and transportation policies and investment in order to support resilient and dynamic regions and communities throughout the Commonwealth

Land use, transportation, and economic development are inextricably linked, but that linkage is often not reflected in public policy or public investments. High-density land use, a characteristic central to the definition of a city, generates significant transportation demand and economic activity. Areas of less density have different types of mobility and economic needs and patterns. The Commission focused on how potential future economic, social, technological, and environmental trends could impact the regions and municipalities of the Commonwealth differently, and also how policies set at the local, regional, and state levels in turn influence all of those trends. The Commonwealth's plan to address future transportation challenges will require different responses for different areas, as well as grappling better with the policy and funding disconnects between land development and transportation investment.

Many Gateway Cities – as well as large parts of eastern Massachusetts - are served by the MBTA's commuter rail system, but that service was designed and is primarily operated to support weekday workers who need to get to Boston. MassDOT and the MBTA are investigating how the system could be reshaped to serve a broader spectrum of travel. Substantially improving connectivity to and among Gateway Cities and the regions they anchor and other regional hubs requires thinking about and serving their mobility needs differently from what is done today.

Rural Massachusetts is not effectively served by passenger transportation modes other than personally-owned vehicles. In many cases, existing alternatives have failed to provide meaningful transportation options in many rural towns. Bus service offered by Regional Transit Authorities (RTAs) is limited outside of priority corridors; passenger rail service is limited west of Fitchburg; transportation network companies (TNCs) are economically inefficient in low-density areas. The Commonwealth, in partnership with the private sector and other stakeholders, needs to find a better answer to low-density and rural mobility needs than it so far has.

For more information, [please see Volume II](#).

13. Adopt land use policies and practices that support more dense, mixed-use, and transit-oriented development (TOD).

Municipalities should accelerate the adoption of land use regulations that promote density and the use of shared and multi-passenger vehicles. As the state, cities, and towns plan for the dynamic changes associated with transportation innovation in 2040 and beyond, they must consider the effect that transportation innovations will have on potential redevelopment sites, parking needs, curb management, and local infrastructure requirements as they update master plans, zoning, permitting processes, and building codes. This makes it easier for businesses to attract employees living without a car (or preferring not to commute with one), while creating a built-in market for the amenities that most cities and towns are actively trying to offer.

Municipalities should adjust development policies and actions to support density and promote active and shared transportation modes. It is essential that municipalities create and implement land use plans that focus new development in transportation-efficient locations. For example, municipalities with significant transit or private ridesharing use could dedicate rights of way (ROW) as designated pick-up and drop-off locations in order to reduce congestion and safety risks. Similarly, local land use planners could ration and dedicate spaces on and off roadways for biking, walking, and other modes of active travel to reduce reliance on personal vehicles and create environments that are safer for all types of mobility. As parking needs change, municipalities should move away from building stand-alone parking garages and should prepare adaptation plans for existing parking structures. Similarly, on-street parking spaces could be reallocated for transit, shared and autonomous vehicles, or other modes.

The state should consider supporting local advancements through incentives and regulations. Agencies should focus development programs like the MassWorks Infrastructure Program, the Infrastructure Investment Incentive Program (I-Cubed), and locally funded programs like District Improvement Financing (DIF) on high-density or transit-oriented locations. The state can continue efforts to revise zoning laws to promote density and allow for mixed-use opportunities, including financial incentives for transformative zoning proposals. Funding for affordable housing should focus on access to public transportation and alternative modes.

Why is this Recommendation Important?

- There is a strong interconnection between land use, housing, and the economy that can be more effectively addressed through specific actions and better coordination.
- TOD and dense development in appropriate locations offer many important positive attributes, including the mitigation of environmental concerns and the possibility of improved access to public transit.

Some Initial Steps

1. Cities and towns should update local zoning codes and master plans to create more infill development and encourage higher-density mixed uses near transit stops and stations.
2. Cities and towns should create parking management plans that reconsider the role of parking in local development and promote shared or reduced parking balanced by transit-friendly development practices.
3. The Board of Building Regulations and Standards should incorporate transit, active transportation, and new mobility services like TNCs and shared vehicles into the building codes (e.g. pedestrian- and bike-friendly measures including sidewalk treatments and lighting, bus shelters, bicycle storage, and shower facilities).

4. State agencies, including HED, MassDOT, EEA, and entities like MassDevelopment should better coordinate their policies and investments to support the policies and practices described. The state should consider supporting local advancements through incentives and regulations.

14. Use land use, economic development, and transportation policies and investment to enable Gateway Cities and the regions they anchor throughout the Commonwealth to compete for the growing number of residents and jobs.

This recommendation is a companion to both Recommendation 13 related to land use, economic development, and transportation policies and practices, and also to Recommendation 15 related to re-envisioning the MBTA commuter rail.

The Commission encourages state transportation providers – including MassDOT, MBTA, and the RTAs – to take active steps to support the opportunities for housing and economic development of Gateway Cities and other regional hubs that have the potential to act as economic anchors within their respective regions and ridership for public transit. The built environment and street networks of these older regions, coupled with their receptive municipal attitudes towards growth, make them fertile ground for expanding opportunities for economic investment and housing.

Because local cities and towns will know what could work best in their communities, the Commission proposes that these hub cities and local municipalities take the lead in developing the economic and housing plans that can maximize the opportunities for their respective regions. Transportation agencies, along with other state agencies, including HED and EEA, should play an important role in supporting the development of these regional hubs cities as anchors for distinct and economically competitive regions. The Commission supports the intentional transportation investments that allow Gateway Cities and other regional hubs to grow and thrive, both within their respective region and between regions and metro-Boston. This includes the roadways, rail system (as noted in Recommendation 15), and other improvements to increase shared rides, reduce pollution, expand opportunities for walking and biking, and provide more options for micro-mobility. The RTAs should play a key role in these efforts.

Why is this Recommendation Important?

- The relative scarcity of land proximate to high-functioning transportation infrastructure has led to unsustainable price escalation in the Boston region, in both the commercial and residential markets.
- Gateway Cities and other regional hubs have many of the amenities that prospective employers, entrepreneurs, and residents seek but often find unaffordable closer to Boston.
- As the cost of doing business continues to rise in Boston, companies may be more likely to seek space in lower cost locations outside the inner core.
- The Massachusetts' Economic Development Agenda is focused statewide on Gateway Cities, and it is important to complement economic development initiatives with transportation investments.
- Gateway Cities and similar regional hubs have higher rates of residents who are unemployed and have low-incomes and households without access to a car than other communities in Massachusetts. Robust public and other transportation modes that connect burgeoning and existing job hubs to housing and each other helps address concerns of economic equity for both people and places.

Some Initial Steps

1. MassDOT should develop a policy that supports the revival of historic downtowns as regional hubs through improved transit service and prioritization for investments.
2. Through its Rail Vision process, the MBTA should develop Gateway City-focused scenarios.
3. Municipal leaders and MPOs should convene to develop comprehensive efforts to outline strategies for economic growth and housing that clearly references transportation policies and investments.
4. RTAs serving identified potential hubs should develop conceptual service plans showing what a more downtown-centric network, including express connections to other nearby hubs where applicable, might look like.

15. Coordinate the planned reinvention of the MBTA commuter rail system with local, regional, and state land use and economic development strategies to maximize the ridership and economic benefits of the reinvented system.

The MBTA should work with stakeholders to compile a menu of new service options for the commuter rail network by the end of 2019 and develop detailed information on the costs (both capital and operating) and benefits of each of the service models. The goal of this exercise is to re-orient the commuter rail from its current configuration as a commuter train taking passengers to and from Boston to a regional train system that connects hubs and serves the region all day, every day. For this process the MBTA needs to consider the needs of all other travelers who would rely on and use the system if it were adequately configured to take them where they need to go and when they need to go. Stakeholders include the Rail Vision Advisory Committee and leaders of municipalities, businesses, key institutions, and surrounding communities, as well as riders themselves.

Regional planning officials and local elected officials in commuter rail served communities should develop plans to support near-term increases in ridership and the transition to broader, interconnected service models. Municipalities are as important as the MBTA in developing and implementing a high-functioning, high-capacity rail network, because in order for commuter rail to be beneficial, it must take riders to places that they want to go at either ends of the trip and make the experience convenient and comfortable enough to compete with personal vehicle travel. As suggested by the MassINC Gateway Cities Innovation Institute, Gateway Cities with rail service could support high-density development using a combination of Opportunity Zone and other resources to help make development deals work. Prioritizing land near transit for high-density residential and commercial development provides an attractive, more affordable alternative option for people to live and work. It is important that residential developments include workforce and affordable housing options, rather than solely focusing on luxury development, as populations with middle- and lower-incomes are already incentivized to choose transit when it is available.

Why is this Recommendation Important?

- The current MBTA commuter rail system serves nearly 80 cities and towns, but carries only 122,000 daily trips, indicating that commuter rail may be an underused asset.
- The MBTA has launched a Rail Vision study to better understand the potential impact of new service models on ridership. Potential new service models under review include regional rail (more frequent service throughout the day) and urban rail (using smaller vehicles to provide transit-like service on at least the more urbanized portion of the network).
- While some stakeholders have called for radical reinvention of the commuter rail system including full electrification and a complete changeover in both its service model and infrastructure, no framework is in place to move this agenda beyond the completion of the Rail Vision study in 2019.
- The upcoming re-procurement of the commuter rail contract (which expires in June 2022) presents a target against which to accelerate efforts to understand in greater detail both the costs and benefits of a reinvented rail network and service that could be phased in and fully operational before the 2040 time horizon of this Commission Report.

Some Initial Steps

Upon completion of the Rail Vision study, the MBTA should:

1. Where feasible, use pilots on specific rail lines to test the viability of proposed new service models.
2. Develop a viable business/operating/financial model for the new rail network that can support its operating and capital costs.
3. With the current commuter rail operating contract set to expire at the end of June 2022, re-procure the new contractual arrangement in a manner that accelerates the changeover to the new service model(s), possibly through a longer-term public-private partnership/joint venture approach that can support at least some of the capital investment needed to support the new service model(s).

16. Provide better mobility options in rural communities through reimagined public transportation, community transportation services, and public/private partnerships.

MassDOT, working with MPOs and local municipalities, should develop strategies for providing rural Massachusetts with viable transportation options that supplement privately-owned vehicles. The Commonwealth should designate appropriate state agencies to work with the private sector to ensure that necessary infrastructure is available to support the deployment of C/AV and TNC technologies throughout the state, including rural areas.

Why is this Recommendation Important?

- Rural Massachusetts is served minimally, or not at all, by any passenger transportation mode other than personally owned vehicles. This disadvantages those people and families who suffer economic hardships, or have limitations on their ability to drive. Some local resources in rural areas have developed to try to fill the gap, but rural populations remain difficult to serve. Many rural towns have no or minimal bus service, train service, or access to TNCs.
- Households without cars in rural areas are disadvantaged on the issue of transportation. Alternatives to privately owned vehicles have failed to succeed in many rural towns, partly because low population density makes these options economically unattractive. Similarly, rural communities cannot participate in transportation technologies if the infrastructure that underlies them does not exist.
- The current inability to keep up with advanced telecommunications needs today in rural Massachusetts has implications for the use and integration of future transportation technologies that could help respond to the challenges of transportation in low-density areas.

Some Initial Steps

1. The Governor should direct the appropriate state entities to work with the private sector to ensure that all necessary infrastructure is available to support the deployment of C/AV and TNC technologies across the state, including rural areas.
2. MassDOT, MPOs, and local municipalities should evaluate the ability of the current RTA structure to address public transportation needs in rural areas and how TNCs and other alternatives may supplement services.
3. MassDOT, MPOs, and local municipalities should evaluate feasibility of coordinating local transportation resources, including RTAs, school buses, Councils on Aging, MassHealth, and private van services to understand the obstacles to and options for sharing of transportation assets.
4. MassDOT should continue to assess the feasibility of increased transportation service, including rail service, to rural areas of the state to connect them to larger urban areas both inside Massachusetts and in neighboring states.

V. Make changes to current transportation governance and financial structures in order to better position Massachusetts for the transportation system that it needs in the next years and decades

The creation and maintenance of a well-functioning transportation system is a core government responsibility and a key public service that is integral to the health and well-being of our residents and our economy. It is critical, then, that our governance structures evolve to meet the state's rapidly changing needs and provide sufficient resources for its proper functioning.

The way that Massachusetts meets transportation needs today will likely not suit its needs in the future. This challenge is not unique to the Commonwealth: all departments of transportation are faced with similar questions. In recognition of the need to adapt current practices, today's approaches to governance and resources must be re-examined and re-imagined in order to better position Massachusetts to meet its future transportation goals.

A statewide transportation system that provides safe, reliable, and multi-modal transportation options will require more than significant new infrastructure investment; it will also require a new way of thinking about the system as a whole and the assets that comprise it. The near and long-term success of our transportation network needs an accurate cost assessment of what it will take to not only operate but properly maintain critical assets and services. These expenses should then be met with revenue streams that are of equal value and prudently managed by appropriate personnel. As a first important step, today's decision makers should commit to addressing long-standing priority deferred maintenance and state of good repair needs of the state's existing assets by 2030. This would enable the Commonwealth to approach 2040 in good physical and financial shape and allow for sound decisions on what types of investment are needed for the future transportation infrastructure network.

For more information, [please see Volume II](#).

17. Prepare MassDOT and other transportation-related entities to effectively oversee a changing transportation system.

The Governor should consider specific changes to MassDOT and other agencies that allow better focus, alignment, and results. The Commission finds a need for MassDOT to be the agency that embraces the future of mobility, aggressively explores how to take advantage of new technology and service approaches, and how to envision new ways of the public and private sector to work together.

To prepare the Commonwealth's transportation network for the inevitable changes of tomorrow, the state needs better data, greater focus, and better adherence to best practices, as well as improved management and oversight to better plan for and more quickly react to the evolving transportation environment.

Our specific recommendations include:

1. A dedicated MBTA Board;
2. Explicit coordination around housing, economic development, environment, and transportation;
3. A new paradigm for MassDOT, MBTA, and RTAs that includes internal capacity building to support future preparedness and innovation initiatives;
4. Closer collaboration and shared goals between MassDOT and other agencies to allow better focus, alignment, and results;
5. Data-sharing that protects privacy while enabling improved services, traffic operations, and integrated mobility options; and
6. Release from limited ways of doing business.

Why is this Recommendation Important?

- Given that form follows function, the items in this recommendation create the organizational form that enables the improved functioning of MassDOT and related agencies.
- The Commonwealth needs to address the role of public transportation at a time of rapid change – in technology, in the possibilities of data-sharing, in the role of the private sector. Our challenge is to have public agencies that prioritize collaboration, enable innovation, and are prepared for change.
- These specific items present some of the issues that should be done initially to strengthen MassDOT and provide the basis upon which to build a more effective transportation system. Some of what the Commission is proposing may be accomplished administratively; other elements may require legislation.

Some Initial Steps

1. The Governor should establish a dedicated MBTA Board to oversee operations. The evidence is overwhelming that a dedicated board or similar entity is critical to improving the MBTA's operations, fiscal soundness, and capital planning. Any such dedicated MBTA Board must have a close, if not, integral relationship to the overall MassDOT Board to ensure strong coordination. A reliable, efficient, and customer-oriented MBTA is the cornerstone of our current and future transportation system. Like MassPort and MWRA, it should have a clear governance model, be responsible to its key constituencies, and be a strong partner to other public sector and private sector entities. A key factor to the MBTA's success will be its capacity to procure goods and services as cost-effectively as possible with

increased vendor accountability. Like MassPort and the Massachusetts Water Resources Authority (MWRA), MBTA should have the means to improve procurement results and be exempted from the current procurement restrictions, which are unnecessarily burdensome. This exemption was successfully piloted along with the creation of the Fiscal and Management Control Board.

2. The Governor should more closely align and better integrate housing, economic development, environment, and transportation policies to achieve the Commonwealth's transportation and economic development goals. The Commission recommends the creation of an explicit relationship between MassDOT, EEA, and HED, working with other entities such as MassDevelopment, MPOs, and municipalities to drive smart transit, housing, and economic development and address regional transportation and environmental and climate resiliency issues.
3. The Governor should advance a new paradigm for MassDOT, MBTA and RTAs. The current model of each RTA as a stand-alone entity does not maximize opportunities, effort, and resources. The capabilities and services of the Regional Transit Authorities (RTAs) are mixed, as is the sharing of expertise or coordination of planning and potential common purchases and services. A new dynamic relationship between MassDOT/MBTA and the Regional Transit Authorities (RTAs) that would foster joint planning, purchasing, and sharing of information, experience, and expertise would improve coordination and regionalization of services and should be pursued.
4. The Governor should consider specific changes to MassDOT and other agencies that allow for better focus, alignment, and results. The appropriate scope of MassDOT's jurisdiction should also be reviewed with the goal of creating a transportation agency that oversees a fully integrated transportation system to meet current and future needs. This review could examine whether Department of Conservation and Recreation (DCR) parkways, other transportation assets, and oversight of TNCs falls more properly within MassDOT than other agencies.
5. The Governor should task the Executive Office of Technology Services and Security (EOTSS) and MassDOT to develop a plan within twelve months to best support data-sharing to enable improved services and options for the Commonwealth's transportation system. Data-sharing is and will be the basis of how we approach so much of our transportation system, including traffic flow, congestion, shared-rides, integration between different travel modes, first and last mile solutions, and the basic functionality of connected/autonomous vehicles (C/AVs). Data-sharing is not only critical for many of the developing transportation technologies, evaluation of data is an important driver of how services are provided to best meet real-time needs. An effective way to share data – and protect privacy – is a building block of our future transportation system. There are various efforts at transportation data-sharing in different stages of development. EOTSS and MassDOT should evaluate local, regional, and national efforts that support public and private entities to share appropriate information while ensuring protection of personal privacy and should make a recommendation within twelve months.

18. Develop a fiscally sound and responsible transportation resource plan to operate, maintain, and upgrade the transportation system.

MassDOT should develop a transportation resource plan that includes projected expenses and revenues built upon a robust asset plan with staff and expertise to plan, operate, and innovate. Among the most significant contributions that today's decision makers could make to the public for the year 2040 is to commit to providing sufficient resources for the proper maintenance, operation, and upgrades to the state's transportation network. The Commission concludes its report with this recommendation, not because it is the least important, but, rather, because the promise found in our earlier recommendations can only be achieved through a long-term commitment to providing the resources necessary to operate and maintain the Commonwealth's evolving transportation system. This begins with a commitment to eliminate the longstanding backlog of today's identified priority deferred MBTA and MassDOT maintenance projects to achieve safe, efficient services and asset conditions by 2030. Only then will the Commonwealth be able to fully turn its attention to effectuating the Commission's vision for 2040.

There are four pillars upon which our transportation resource plan should be built:

1. **Maintenance and modernization.** The resource plan must begin with the creation of an asset management plan that identifies the investments necessary to get and keep the state's existing transportation assets and municipal roads into a state of good repair by 2030. It must also account for systemic changes necessitated by technological advances, such as fare automation, mobile applications to enhance customer service, capacity enhancements, and other such improvements.
2. **Climate resiliency.** Resiliency efforts, both for existing infrastructure and planned/new projects, represent new costs that must be acknowledged in both operational and capital budgets.
3. **De-carbonization.** De-carbonization. As discussed, the electrification of transportation will have to be an important part of meeting our GHG goals. The upfront costs associated EV infrastructure will be significant, but there will be significant climate benefits and potential other net long term economic benefits. The full range of potential revenues, costs, and benefits will be needed to inform policy makers.
4. **Priority Investments.** Projects should be prioritized according to clearly articulated and measurable transportation goals, such as transporting the most riders, alleviating congestion, providing service to underserved areas, or other such criteria.

This is not a one-time exercise; rather it is a new, more comprehensive, and integrated approach to how the Commonwealth can properly budget for all transportation assets that should be performed annually. A similar process should also be required for municipal assets and by the Regional Transit Authorities. Sustained commitment will enable the state to approach 2040 in good structural and financial shape.

Why is this Recommendation Important?

- Among the greatest impediments to delivering the highest levels of service today and advancing the transportation network the Commonwealth could have tomorrow is the lack of attention to plan and/or adequately budget for routine maintenance and upgrade of the system's infrastructure and services. As a result, the state is burdened with problems that range from the famed 2015 winter shutdown of the MBTA to the less noticeable but more

widespread and insidious increase in costs and diminished service delivery from the backlog of needs.

- The Commission recognizes that significant strides have been made in the past several years on the planning, budgeting, and implementation necessary to address these legacy issues and put the Commonwealth on a secure path forward. This has been true for the MBTA, as well as a number of other high profile transportation projects throughout the Commonwealth. But, it is important that the Commonwealth recognizes and accepts that more must be done to support all three components: planning, funding, and implementation.
- There are three principles to guide resource planning, and implementation. First, financial resources must be used effectively. As an example, the recent success of the MBTA's Fiscal and Management Control Board (FMCB) and management team's ability to achieve significant cost savings while increasing capital investment, improving customer service and operating capacity. Second, the Commission supports the increased outlay necessary to improve the budgeting and planning process because it believes it will pay handsome dividends in the future. Third, the resource plan needs to leverage both public (state and municipal) and private resources where possible. While traditional revenue sources such as user fees and increased taxes must be considered, revenue generation from real estate, advertising, and other operations need to be maximized. Value capture, business improvement districts, regional ballot initiatives, and other approaches also need to be leveraged.
- The Commission's goal is to ensure a sustainable and fair funding approach to our transportation system for its operation, maintenance, and improvement, including those improvements necessary for climate resiliency, de-carbonization, and technological advances. Costs for the system should be reasonably and transparently distributed among individual and commercial users, taxpayers, municipalities, and the Commonwealth. The number of resources that will be necessary to adequately address any one of these components will be significant and require some difficult trade-offs within transportation investments and likely between transportation investments and other state expenditures. However, having a realistic picture of the resources required is crucial for moving forward. This challenge is exacerbated by the fact that many technological advances in transportation threaten to diminish current revenue sources.

Some Initial Steps

1. MassDOT, in conjunction with the Executive Office for Administration and Finance (A&F) and the MBTA, should develop a finance plan that pays for current expenses, as well as eliminates the backlog of today's identified priority deferred MBTA and MassDOT maintenance projects to achieve safe, efficient services and asset condition by 2030, and funds appropriate and prudent upgrades and expansions with full accounting of the additional operating costs that will result from them. Transportation funding should be prioritized so that the Commonwealth can address current needs first, determine how to pay for enhancements and expansions of the current system next, and then focus on transformational investments. These investments need not be sequential; in fact, investments related to climate resiliency, de-carbonization, and other modernization can and should be considered for any deferred maintenance project.
2. MassDOT and the MBTA should work with A&F to compile a list of current and potential revenue sources and their risks and alternatives and update it annually. A finance plan should also be developed that evaluates the needs, funding sources and expenses for the transportation assets under municipal and RTA jurisdiction.

3. MassDOT and the MBTA should pursue an up-to-date asset management system so that it accurately includes the cost for properly maintaining all assets, climate change adaptations, and considers technological needs.
4. MassDOT and the MBTA should develop a staffing plan that allows for the broad set of responsibilities to be performed efficiently and effectively. A world-class transportation system needs a top-talent team. The financial plan should reflect these additional costs to maintain, attract, and develop the management and staff team.

Going Forward

We are humbled by transportation.

...By how essential it is to how we live.

...By how very personal it is.

...By its public sector features.

...By how the private sector depends upon, imitates, and goes beyond the public sector.

...By how quickly it is changing in mode, service, operations, information, and more.

There is a quote from Aristotle that is relevant for our work: “The more you know, the more you know you do not know.”

Then there’s a quote from Bill Gates: “We always overestimate the change that will occur in the next two years and underestimate the change that will occur in the next ten. Don’t let yourself be lulled into inaction.”

For those of us on the Commission, we have learned much, but we also became aware of how much more we do not know, especially in looking out to the next couple of decades.

Given time constraints, the Commission’s focus was on the movement of people. Though the Commission learned that freight is expected to double in the timeframe of this report (i.e., by 2040), the Commission lacked the time to get to the movement of things. The Commission learned that it is participating in and witnessing an absolute revolution in how things are being delivered and moved around the country and our state, and that there is a term that some use for internet shopping and its subsequent impacts on transportation: the Amazon effect. Like freight, many of us have also just begun to explore the potential of marine transportation, as well as the challenges and opportunities of air travel of all kinds. While some interesting developments are anticipated with air travel, the Commission did not think that this would be a significant impact within the next 20 years. It is to the hope of the Commission that we are not like Thomas Watson, head of IBM, when he predicted that computers were largely unnecessary innovations that would have little impact on the world as we knew it. Predicting the future is tough business. In each of these areas, freight, marine transportation, and air travel, there is more work that needs to be done.

Going forward, the Commission proposes that the Governor establish an effective way to review the state of our transportation system. This review could include the recommendations in this report, critical benchmarks, and other considerations as determined by the Governor. The Commission believes that this review should be independent of the agencies involved. It should engage statewide representation and could include an annual presentation and report to Governor and legislative leadership, as well as a public forum where this information is presented. The Commission believes that this type of oversight will allow the opportunity to look at, evaluate, poke, prod, cheerlead, and frown on how we as a Commonwealth are doing when it comes to our transportation system.

We hope that this report has provided a strong base of information, long-term directional guidance, and specific near-term steps to help prepare Massachusetts to meet the challenges ahead.

Thank you for this opportunity.