Final Project Report

Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning

Prepared for **Teaching Old Models New Tricks (TOMNET) Transportation Center**

TOMNET Transportation Center
Teaching Old Models New Tricks

Arizona State University Georgia Tech UNIVERSITY of WASHINGTON USF UNIVERSITY OF SOUTH FLORIDA

By

Thaddeus R. Miller
Email: thaddeusmill@umass.edu

Ram M. Pendyala
Email: ram.pendyala@asu.edu

Devon McAslan
Email: devon.mcaslan@asu.edu

Max Gabriele
Email: N/A

School of Sustainable Engineering and the Built Environment
Arizona State University
Tempe, AZ

August 2020

TECHNICAL REPORT DOCUMENTATION PAGE

1. Report No. N/A	**2. Government Accession No.** N/A	**3. Recipient's Catalog No.** N/A
4. Title and Subtitle Emerging Approaches to Autonomous Vehicles in Transportation Policy and Planning		**5. Report Date** August 2020 **6. Performing Organization Code** N/A
7. Author(s) Thaddeus Miller, https://orcid.org/0000-0002-1692-5839 Ram M. Pendyala, https://orcid.org/0000-0002-1552-9447 Devon McAslan, https://orcid.org/0000-0003-4333-3991 Max Gabriele		**8. Performing Organization Report No.** N/A
9. Performing Organization Name and Address School of Sustainable Engineering and the Built Environment Arizona State University 660 S. College Avenue, Tempe, AZ 85287-3005		**10. Work Unit No. (TRAIS)** N/A **11. Contract or Grant No.** 69A3551747116
12. Sponsoring Agency Name and Address U.S. Department of Transportation, University Transportation Centers Program, 1200 New Jersey Ave, SE, Washington, DC 20590		**13. Type of Report and Period Covered** Research Report (2019 – 2020) **14. Sponsoring Agency Code** USDOT OST-R
15. Supplementary Notes N/A		

16. Abstract

Autonomous vehicles (AVs) are rapidly emerging in United States cities, leaving urban and regional planning institutions unsure how to plan and develop policies. This paper analyzes how regional transportation plans (RTPs) developed by metropolitan planning organizations (MPOs) are approaching the risks and opportunities presented by AVs. Among 52 MPOs, a majority only mention key issues and emphasize high levels of uncertainty. Twelve MPOs develop policies on infrastructure, safety, partnerships, data-sharing, and multimodal transportation. Despite a positive trend, many recently adopted RTPs do not incorporate AVs. To plan for uncertain mobility futures, MPOs must develop more flexible approaches to long-term infrastructure investment.

17. Key Words Autonomous vehicles, Transportation planning, Metropolitan planning organization (MPO), Regional transportation plan (RTP), Autonomous vehicle policy		**18. Distribution Statement** No restrictions.	
19. Security Classif.(of this report) Unclassified	**20. Security Classif.(of this page)** Unclassified	**21. No. of Pages** 35	**22. Price** N/A

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

DISCLAIMER

The contents of this report reflect the views of the authors, who are responsible for the facts and the accuracy of the information presented herein. This document is disseminated in the interest of information exchange. The report is funded, partially or entirely, by a grant from the U.S. Department of Transportation's University Transportation Centers Program. However, the U.S. Government assumes no liability for the contents or use thereof.

ACKNOWLEDGMENTS

This study was funded by a grant from A USDOT Tier 1 University Transportation Center, supported by USDOT through the University Transportation Centers program. The authors would like to thank the TOMNET and USDOT for their support of university-based research in transportation, and especially for the funding provided in support of this project.

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY
Autonomous vehicles (AVs) are rapidly emerging in United States cities, leaving urban and regional planning institutions unsure how to plan and develop policies. This paper analyzes how regional transportation plans (RTPs) developed by metropolitan planning organizations (MPOs) are approaching the risks and opportunities presented by AVs. Among 52 MPOs, a majority only mention key issues and emphasize high levels of uncertainty. Twelve MPOs develop policies on infrastructure, safety, partnerships, data-sharing, and multimodal transportation. Despite a positive trend, many recently adopted RTPs do not incorporate AVs. To plan for uncertain mobility futures, MPOs must develop more flexible approaches to long-term infrastructure investment.

INTRODUCTION

The development of autonomous vehicle technology has advanced rapidly over the last decade (Ford, 2019; Korosec, 2019; Szymkowski, 2019). Autonomous vehicles (AVs)—vehicles that are capable of driving and navigating with limited or no human controls—are being tested and deployed in limited demonstration and pilot projects in dozens of cities across the United States (Bloomberg Philanthropies, 2019; Chatman and Moran, 2019; Haque and Brakewood, 2020). Despite this increased activity and deployment of AVs on public roads, federal, state, and local policy and planning development has been slow. A recent review of city comprehensive and transportation plans shows that a small percent of cities nationwide are integrating AVs into their planning efforts (Freemark et al., 2019). As AV technology matures and is deployed in increasing numbers and locations, it is critical for urban and regional planning institutions to develop technology assessment methods, policies, and plans now.Transportation planners have also recognized that machine learning methods demonstrate high predictive performance and computing efficiency for large-scale mobility datasets, but those data-driven approaches still need to systematically meet standard requirements and expectations associated with modeling travel data sets (e.g., travel surveys) in transportation planning. The desirable statistics-oriented features include illustrating causal relationships, avoiding overfitted results in relatively small data sets, as well as generating robust standard error estimates for hypothesis testing. If a model estimates only the correlation in a given data set, as pointed out by Mokhtarian (2018), the causation would be eliminated, impeding the ability to answer "why" and "what might happen if" questions. Importantly, incorporating these factors enables researchers and decision makers to deeply fathom the traveler's behavioral patterns. In light of this, statistical modeling approaches have generally been applied in explaining the cause-and-effect relationship and analyzing travel survey data (Paredes et al., 2017; Brathwaite and Walker, 2018).

Transportation planning at the regional level is a collaborative process that uses data (e.g., population growth, trip forecasting, travel demand analysis, etc.) to assess infrastructure needs and build the infrastructure (e.g., roads and highways) needed to support anticipated urban growth (USDOT, 2001). Increasingly, cities and regions are investing in multimodal transportation systems, with more money going to major public transit infrastructure projects (e.g., light rail and streetcar). Over the last decade, shared and smart mobility (e.g., dock-less bikeshare, e-scooters, car sharing, and ride-hailing) have emerged with still uncertain impacts on travel behavior and challenging transportation planning processes (Duarte and Ratti, 2018; Grahn et al., 2019; Polzin, 2018). In the face of these changes, urban and transportation planners have found themselves unprepared for understanding and addressing their impacts (Clewlow, 2017; Cugurullo et al., 2020; Curtis et al., 2020; Pankratz et al., 2018). The long-term impacts of these new mobility options are poorly understood, and they are rarely factored into transportation investment decisions. This is due to their novelty and the uncertainties around how these technologies and services will evolve, to what extent they shape travel behavior, and what their infrastructure requirements are.

Given the critical need for urban and transportation planners to be planning for AVs, this article examines what efforts are already underway. We examine activities of metropolitan planning organizations (MPOs) in the United States and ask two primary questions: How are MPOs planning for AVs? and What are the common issues and approaches that MPOs consider in planning for AVs and their place in future transportation systems? This research builds upon and updates Guerra's (2016) study that examined the 25 largest MPOs and their regional transportation plans (RTPs). Since then, there has been significant development in AV technology, testing, and piloting as well as the launch of Waymo's commercial AV ride-hailing service (Miller and McAslan, 2019). Additionally, these plans are updated every four years, meaning that all of these plans analyzed by Guerra have been updated at least once.

This presents a unique opportunity to examine the pace at which urban and transportation planning institutions have been able to keep up with rapid advances in transportation technologies. Guerra (2016) found that only one MPO mentioned AVs in their RTP. Given the fact that these plans have all been updated and the significant developments around AV technology and deployments, we would expect planning efforts to evolve, despite high uncertainty about the impacts and deployment of AVs. Despite uncertainties about technological advancements and viable business models, planners must still make decisions about transportation investments in ways that guide the development and deployment of emerging technologies to advance policy and planning goals related to sustainability, equity, economic development, etc. In this article, we examine the most recent RTPs of the 52 largest MPOs in the United States, making it the most comprehensive analysis of regional efforts to plan for AVs to date. Our goal is to understand the current state of planning surrounding AVs and the ways in which regional transportation planning agencies are adapting to AVs.

THE CHALLENGES OF PLANNING FOR AUTONOMOUS VEHICLES

Automakers, technology developers, city planners, governments, and the media all promote AVs for their ability to save lives, expand mobility options in cities, and help reshape cities in more sustainable ways. However, none of these outcomes is a given and AVs are as likely to have negative impacts in cities as they are to have positive benefits. Until recently, despite the disruptive potential of AVs, even the extant (non-technical) academic literature has been lacking in critical range. Now several papers have provided overviews of the challenge of planning for AVs, characterizing the various stakeholders, outlining frameworks for assessing the impact that AVs might have, and introducing challenging questions that manufacturers, governments, or society will have to grapple with, if and when the technology becomes ubiquitous (Fagnant and Kockelman, 2015; Harb, et al., 2021; Kassens-Noor, Dake, et al., 2020; Thomopoulos and Givoni, 2015; Vellinga, 2017). There have been studies to model the effect AVs will have on congestion, liability, or environmental projections, given particular degrees of fleet penetration (Bagloee et al., 2016; Schreurs and Steuwer, 2016) and arguments for more directly linking this modeling to policy-making (Curtis et al., 2020). Others have built out multiple scenarios of urban futures involving different usership and ownership paradigms (Bahamonde-Birken et al., 2016; Guerra, 2015; Wadud and Chintakayala, 2021). Research has also recently begun to explore the increasing role that AV pilot projects play in planning for autonomous mobility, documenting the general approaches to AV experiments (Dowling and McGuirk, 2020) and lessons learned (Chatman and Moran, 2019; Dennis et al., 2021; Haque and Brakewood, 2020; Steckler et al., 2020).

Science and technology studies scholars have long argued for the need for governance structures, assessment tools, and anticipatory capacities to manage innovations responsibly (Stilgoe et al., 2014; Stilgoe et al., 2013), including AVs. Stilgoe argues for improving social learning, democratizing learning and experimentation, engaging the public around the public value of technology, and fostering collaboration between local governments and AV companies as a way to govern this emerging technology (Stilgoe, 2017, 2018a, 2018b). Others have expanded the analysis beyond "first order" effects (e.g., traffic, collision rates, etc.) into wider, less obvious or immediate societal impacts (e.g., employment, land use, etc.) and to drive home the urgent need for common sense policies to help guide AV technology's growth in a way that will benefit society (Guerra, 2016; Milakis et al., 2017). Urban and regional planning institutions, and perhaps society at large, are presently ill-equipped to plan for and anticipate and manage a driverless future.

Many authors have pointed to the lack of clear regulatory guidelines and standards for safety, performance, and system privacy and integrity (Claybrook and Kildare, 2018; Favarò et al., 2018; Karnouskos and Kerschbaum, 2018). Legal scholars, noting that there are still no federal standards for AVs and that existing policy curtails states' autonomy to sensibly regulate them, have proposed ways federal lawmakers could collaborate with states to establish reasonable standards (Geistfeld, 2018). The lack of regulatory oversight in testing and operation of AVs was a key issue in the November 2019 NTSB report on the 2018 pedestrian fatality involving a self-driving Uber vehicle in Tempe, Arizona. NTSB placed blame not only on the oversight of Uber in regards to its safety drivers, but also the "insufficient oversight of automated vehicle testing" by the Arizona Department of Transportation (NTSB, 2019).

The number of studies seeking to gauge public acceptance and public perception of the new technologies have multiplied (Bergmann et al., 2018; Dennis et al., 2021; Hulse et al., 2018; Kassens-Noor, Wilson, Cai, Durst, & Decaminada, 2020; Kassens-Noor et al., 2021; Millard-Ball, 2018). Himmelreich (2018) pushes the ethical discussion permutations of the trolley problem, complaining that exaggerated focus on dramatic collision scenarios comes at the expense of understanding more common and more relevant "mundane situations" (Himmelreich, 2018). More recently, Martinho et al. (2021) provide an overview of the research on the ethical aspects of autonomous mobility, finding that industry and academic understanding of AV ethics focus on different elements. Other studies unpack the urgent need to enact regulation to ensure that AVs do not exacerbate social inequalities along rural-urban or socioeconomic divides (Brumage, 2018). Even the promise of environmental benefits and reduction of vehicle miles traveled has come under closer scrutiny (Zhang et al., 2018). Outside of the academy, the tragic circumstances in Tempe and Pittsburgh's disappointing experiences with Uber have led city and state governments to question the wisdom of a hands-off approach to regulation of AVs and AV pilot testing.

As MPOs around the United States are generating RTPs to guide the development of transportation infrastructure and strategies of these local governments, the complexity with which these plans deal with AVs should be deepening. Guerra (2016) examined the 25 largest MPOs in the United States to find that only one of these plans mentions AVs, despite the fact that when interviewed, most planners in these MPOs were aware of the possible impacts of AVs on cities and regions and recognized the need to engage in planning for AVs (Guerra, 2016). Similarly, Freemark et al. (2019) find that while planners in city planning and transportation departments are aware of the issues of AVs and the possible impacts on cities, efforts to plan for AVs have generally not yet made it into planning documents. In another study, Freemark, et al. (2020) find that while transportation planners personally support policies for autonomous vehicles, the implementation of policies to minimize the negative impacts of AVs remains limited by uncertainty and legal and political obstacles (Freemark et al., 2020). Given this observed lack of inclusion in planning documents, the goals of this paper are to examine the extent to which this remains the case at the regional scale within RTPs, or whether, as we would hope, that a higher proportion of MPOs include AVs in their RTPs and to identify the issues that they are concerned with.

METHODOLOGY

This research examines the largest US regions and the RTPs developed by their respective MPOs. MPOs are required to develop RTPs which plan a region's transportation infrastructure needs over at least a 20-year time horizon and are updated every four years. The RTP must "identify how the region will manage and operate a multi-modal transportation system to meet the region's economic, transportation, development and sustainability goals" (Federal Transit Administration, 2016).

We examine the RTPs of all MPOs in metropolitan statistical areas (MSAs) over 1 million people as of the July 1, 2017 population estimates compiled by the US Census. A total of 53 MSAs meet this threshold, which account for 54 percent of the US population. However, in two instances, an MPO encompasses multiple MSAs, while in one instance there are two MPOs in a single MSA. As a result, our final sample includes 52 MPOs, shown in Table 1.

After identifying the regions, we collected the RTP from the MPO website or contacted planners at the organization to obtain a copy. To have the most recent and up-to-date plans, we used both adopted plans and draft plans that were available for public review. We collected RTPs at two points in our research process. The first set of plans was collected in August and September 2018. As we will discuss in the following sections, we identified a significant trend towards policy developing within newly adopted RTPs. In order to track the extent to which this trend was maintained through the next round of plan updates, we conducted another sampling of RTPs in September-October 2019 to include those plans that had most recently been adopted. In the intervening year, three draft plans in our initial sample were adopted, nine of the 52 MPOs updated and adopted new RTPs, and three MPOs currently in an RTP update process had drafts available for public comment. Additionally, five MPOs are currently conducting updates, but draft plans were not yet publicly available. This updated sample allows us to consider how well the trend we initially identified remained once a significant proportion of MPO plans went through an additional update process.

Our methodology builds upon that used by Guerra (2016) by more than doubling the number of RTPs examined to get a more complete picture of transportation activities surrounding AVs. As in the Guerra (2016) article, we conducted a keyword search of each of the 52 RTPs for terms and phrases related to AVs, including "autonomous," "automated," "self-driving," "AV," as well as other terms often associated with automated vehicles, such as "connected," "smart," "emerging," "technology," and others. Plans that included these terms were included in a content analysis to identify the main themes and trends in regional planning efforts in the United States for automated vehicles.

Table 1 Sample of Metropolitan Statistical Areas and the MPO plans analyzed

	City/Region	Metropolitan Planning Organization	Plan Year(adopted)	Regional Transportation Plan
1	Atlanta	Atlanta Regional Commission	2013 (updated 2018)	The Atlanta Region's Plan
2	Austin	Capitol Area Metropolitan Planning Organization	2015 (update in progress)	CAMPO 2040 Regional Transportation Plan
3	Baltimore	Baltimore Regional Transportation Board	2016	Maximize 2040
4	Birmingham	Regional Planning Commission of Greater Birmingham	2019 (draft)	2045 Regional Transportation Plan
5	Boston	Boston Region Metropolitan Planning Organization	2019	Destination 2040
6	Buffalo	Greater Buffalo Niagara Regional Transportation Council	2018	Moving Forward 2050
7	Charlotte	Charlotte Regional Transportation Planning Organization	2018	Transportation for Our Growing Tomorrow
8	Chicago	Chicago Metropolitan Agency for Planning	2018	On To 2050
9	Cincinnati	Ohio-Kentucky-Indiana Regional Council of Governments	2012 (updated 2016)	2040 OKI Regional Transportation Plan
10	Cleveland	Northeast Ohio Areawide Coordinating Agency	2017	AIM (Achieving Increased Mobility) Forward 2040
11	Columbus	Mid-Ohio Regional Planning Commission	2016	2016-2040 Columbus Area Metropolitan Transportation Plan
12	Dallas-Ft Worth	North Central Texas Council of Governments	2018	Mobility 2045
13	Denver	Denver Regional Council of Governments	2017	2040 Metro Vision Regional Transportation Plan
14	Detroit	Southeast Michigan Council of Governments	2019	2045 Regional Transportation Plan for Southeast Michigan
15	Grand Rapids	Grand Valley Metro Council	2015 (update in progress)	2040 Metropolitan Transportation Plan
16	Hartford	Capitol Region Council of Governments	2019	Connect 2045: Metropolitan Transportation Plan
17	Houston	Houston-Galveston Area Council	2016	Bridging Our Communities: 2040 Regional Transportation Plan
18	Indianapolis	Indianapolis Metropolitan Planning Organization	2017	2045 Long Range Transportation Plan
19	Jacksonville	North Florida Transportation Planning Organization	2014 (update in progress)	Path Forward 2040
20	Kansas City	Mid-America Regional Council	2015 (update in progress)	Transportation Outlook 2040
21	Las Vegas	Regional Transportation Commission of Southern Nevada	2017	Access 2040
22	Los Angeles	Southern California Association of Governments	2016	2016 Regional Transportation Plan/Sustainable Communities Strategy
23	Louisville	Kentuckiana Regional Planning and Development Agency	2014	Horizon 2035
24	Memphis	Memphis Metropolitan Planning Organization	2019	Livability 2050
25	Miami	Miami-Dade Transportation Planning Organization	2019 (draft)	Miami-Dade 2045 LRTP
26	Milwaukee	Southeastern Wisconsin Regional Planning Council	2016	Vision 2050

27	Minneapolis-St Paul	Metropolitan Council	2015	Thrive MSP 2040
28	Nashville	Nashville Area Metropolitan Planning Organization	2016	Middle Tennessee Connected
29	New Orleans	New Orleans Regional Planning Commission	2019	Greater New Orleans 2048
30	New York	New York Metropolitan Transportation Council	2017	Plan 2045: Maintaining the Vision for a Sustainable Region
31	Newark	North Jersey Transportation Planning Agency	2017	Plan 2045: Connecting North Jersey
32	Oklahoma City	Association of Central Oklahoma Governments	2016	Encompass 2040
33	Orlando	Metro Plan Orlando	2014 (updated 2015)	Blueprint 2040
34	Philadelphia	Delaware Valley Regional Planning Commission	2017	Connections 2045 Plan for Greater Philadelphia
35	Phoenix	Maricopa Association of Governments	2017	2040 Regional Transportation Plan
36	Pittsburgh	Southwestern Pennsylvania Commission	2019	Smart Moves for a Changing Region
37	Portland	Metro	2018	2018 Regional Transportation Plan
38	Providence	State Planning Council	2017	Transportation 2037
39	Raleigh	North Carolina Capitol Area Metropolitan Planning Organization	2018	Connect 2045: The Research Triangleâ€™s Metropolitan Transportation Plan
40	Richmond	Richmond Regional Transportation Planning Organization	2016	Plan 2040
41	Rochester	Genesee Transportation Council	2016	Long Range Transportation Plan 2040
42	Sacramento	Sacramento Area Council of Governments	2016	Metropolitan Transportation Plan/Sustainable Communities Strategy
43	Salt Lake City	Wasatch Front Regional Council	2019	Regional Transportation Plan 2019-2050
44	San Antonio	Alamo Area Metropolitan Planning Organization	2019	Mobility 2045
45	San Diego	San Diego Association of Governments	2015 (update in progress)	San Diego Forward
46	San Francisco	Metropolitan Transportation Commission	2017	Plan Bay Area 2040
47	Seattle	Puget Sound Regional Council	2018	The Regional Transportation Plan 2018
48	St. Louis	East West Gateway Council of Governments	2019	Connected 2045 (Update)
49	Tampa	Hillsborough Metropolitan Planning Organization	2019 (draft)	It’s Time Hillsborough: 2045 Long Range Transportation Plan
50	Tucson	Pima Association of Governments	2016	2045 Regional Mobility and Accessibility Plan
51	Virginia Beach	Hampton Roads Transportation Planning Organization	2016	2040 Long Range Transportation Plan
52	Washington DC	National Capitol Regional Transportation Planning Board	2018	Visualize 2045

RESULTS

In our 2018 sample, 31 RTPs included AVs. Among these plans, two groups emerged: those RTPs that include more high-level discussions about the impacts of AVs and those that are more specific and have developed policies to guide the development and adoption of AVs. In 2018, 24 of the RTPs only mention AVs while seven plans include policies (See Table 2). Between 2018 and 2019, a total of 12 RTPs were updated, with all but one of these plans moving from having no mention of AVs to mentions or policies. This means that in our 2019 sample, a total of 41 RTPs include AVs—29 mention AVs and 12 include policies (See Table 3). This is a significant change over Guerra's 2016 findings that only one plan mentioned AVs. This shows that MPOs are recognizing the rapid emergence of AVs as an important trend and increasingly incorporating AVs into their RTPs.

Table 2 Level of complexity in AV planning among the 52 MPO plans sampled in Fall 2018. As of 2018, the trend shows a movement towards a more complex discussion of AV issues as MPO adopt new plans that include greater consideration of the impacts and the inclusion of policies starting in the 2017 and 2018 plans

<table>
<tr><th rowspan="2">Level of AV Discussion</th><th colspan="6">Plan Year</th></tr>
<tr><td>2013</td><td>2014</td><td>2015</td><td>2016</td><td>2017</td><td>2018</td></tr>
<tr><td>None</td><td>Detroit</td><td>Louisville
Miami *
San Antonio
Tampa</td><td>Birmingham
Boston *
Grand Rapids
Hartford
New Orleans
Orlando
Pittsburgh
Salt Lake City</td><td colspan="2">Baltimore
Cincinnati Houston
Memphis
Oklahoma City
Sacramento</td><td>Providence
San Francisco *</td></tr>
<tr><td>Impacts</td><td></td><td>Jacksonville
Minneapolis-St Paul</td><td>Austin
Kansas City
Rochester
San Diego *
St. Louis *</td><td>Columbus
Los Angeles
Milwaukee
Nashville
Richmond
Tucson
Virginia Beach</td><td>Cleveland
Denver
Indianapolis
New York
Phoenix</td><td>Atlanta *
Charlotte
Raleigh
Seattle
Washington, DC ^</td></tr>
<tr><td>Policy</td><td></td><td></td><td></td><td></td><td>Las Vegas
Newark
Philadelphia</td><td>Buffalo
Chicago ^
Dallas-Ft Worth
Portland ^</td></tr>
</table>

* Indicates MPOs with stand-alone documents that address AVs and emerging transportation technologies

^ Indicates draft RTP document publicly available but not yet adopted

Table 3 Level of complexity in AV planning among the 52 MPO plans sampled in 2019. A total of 12 plans were updated in 2019, with five plans going from no mention to impacts, and six plans moving from no mention or impacts to policy. Only one plan did not change categories and remained with no mention of AVs

Level of AV Discussion	Plan Year					
	2014	2015	2016	2017	2018	2019
None	Louisville	Grand Rapids Orlando	Baltimore Cincinnati Houston Oklahoma City Sacramento	Providence San Francisco *		New Orleans
Impacts	Jacksonville Minneapolis-St Paul	Austin Kansas City Rochester San Diego *	Columbus Los Angeles Milwaukee Nashville Richmond Tucson Virginia Beach	Cleveland Denver Indianapolis New York Phoenix	Atlanta* Charlotte Raleigh Seattle Washington, DC	Birmingham ^ Boston * Memphis Miami *^ Salt Lake City Tampa ^
Policy				Las Vegas Newark Philadelphia	Buffalo Chicago Dallas-Ft Worth Portland	Detroit Hartford Pittsburgh San Antonio St. Louis *

* Indicates MPOs with stand-alone documents that address AVs and emerging transportation technologies
^ Indicates draft RTP document not yet adopted

KEY ISSUES IDENTIFIED IN RTPs

Among the 41 plans that include AVs in them (as of 2019), there is a large range in the scope of topics covered within them. Many of the MPO plans incorporate AVs into a broader discussion on emerging technologies that will influence transportation within the 20-year horizon of the RTP, including connected vehicles, electric vehicles, ridesharing, and mobility as a service (MaaS), and in a few cases, drones and autonomous aerial passenger vehicles, high-speed rail, and hyperloop. The top 10 issues mentioned in RTPs include safety, ridesharing, land use and parking, public transportation, travel demand and behavior, infrastructure, congestion, mobility and accessibility, road capacity, and ownership. For a complete list of issues covered in RTPs and the core themes of each, see Table 4.

Table 4 Issues and core themes mentioned in Regional Transportation Plan

Issue	Core Themes	Number of Cities	What Cities? Policy or Mention?
Safety	AVs will positively affect vehicle and roadway safety by eliminating human error. There is some concern about how safe AVs will make roads for non-car users (pedestrians, bikes, etc.).	29	Mention: Atlanta, Austin, Birmingham, Charlotte, Cleveland, Denver, Hartford, Indianapolis, Jacksonville Kansas City, Las Vegas, Memphis, Miami, Milwaukee, Nashville, New York, Philadelphia, Richmond, Rochester, San Diego, Seattle, St. Louis, Washington DC Policy: Chicago, Dallas-Ft. Worth, Detroit, Newark, Pittsburgh, San Antonio
Rideshare	Ridesharing, as opposed to private ownership, can help solve congestion problems, reduce parking demand, and provide cheaper transportation; can increase accessibility.	24	Mention: Buffalo, Chicago, Dallas-Ft. Worth, Denver, Detroit, Hartford, Indianapolis, Las Vegas, Los Angeles, Miami, Milwaukee, New York, Newark, Philadelphia, Phoenix, Richmond, Salt Lake City, San Diego, Seattle, St. Louis, Tucson, Virginia Beach, Washington DC Policy: Portland
Land use + parking	AVs may encourage more efficient land uses by reducing the demand for parking (as much as 75 percent) and creating new opportunity for infill development. AVs could also cause more sprawl by reducing the costs associated with travel.	20	Mention: Birmingham, Dallas-Ft. Worth, Las Vegas, Los Angeles, Memphis, Milwaukee, Newark, Philadelphia, Pittsburgh, Raleigh, Richmond, Salt Lake City, San Antonio, Seattle, Virginia Beach, Washington DC Policy: Chicago, Detroit, Hartford, St. Louis
Public transit	AVs could enhance current transit by providing first/last mile connections. Could make transit more efficient by lowering labor cost of transit. Fewer plans mention that lower cost transportation provided by AVs could adversely affect transit, drawing riders away from transit. Several policies aimed at finding ways for AVs to enhance public transit.	16	Mention: Atlanta, Buffalo, Dallas-Ft. Worth, Hartford, Las Vegas, Memphis, Milwaukee, Newark, San Antonio, San Diego, Tampa, Washington DC Policy: Chicago, Philadelphia, Portland, St. Louis
Travel demand + behavior	AVs will likely have significant impacts on travel behavior, but are unknown. Travel demand will likely increase with expanded mobility options.	15	Mention: Atlanta, Austin, Boston, Charlotte, Columbus, Las Vegas, Los Angeles, Miami, Newark, Phoenix, Raleigh, Richmond, Salt Lake City, Seattle, Washington DC
Infrastructure	Emphasis is on providing communication infrastructure for V2 V and V2I communications; MPOs should invest in infrastructure that supports the deployment of AVs, but there is no consensus what this infrastructure looks like.	15	Mention: Indianapolis, Memphis, Raleigh, Richmond, Seattle Policy: Buffalo, Chicago, Dallas-Ft. Worth, Detroit, Hartford, Las Vegas, Newark, Pittsburgh, San Antonio, St. Louis
Mobility + accessibility	AVs will provide new mobility options for previously immobile or mobility limited groups (e.g., children, the elderly, and disabled persons, etc.).	14	Mention: Buffalo, Charlotte, Memphis, Miami, Milwaukee, Minneapolis-St. Paul, Nashville, New York, Newark, Rochester, Salt Lake City, Virginia Beach

			Policy: Detroit, St. Louis
Congestion	AVs may help reduce congestion by operating more efficiently. Several plans also point out studies of ridesharing already contributing to more congestion in cities and cite this as a risk of AVs.	14	Mention: Buffalo, Charlotte, Jacksonville, Las Vegas, Memphis, Miami, Milwaukee, Minneapolis-St. Paul, Nashville, Newark, Rochester, San Diego, Seattle, Virginia Beach
Road Capacity	AVs will significantly increase the capacity of current roadway networks by being able to travel closer together. V2I will allows vehicles to communicate with traffic lights, travel more efficiently, and increase road capacity.	14	Mention: Birmingham, Charlotte, Cleveland, Denver, Las Vegas, Los Angeles, Milwaukee, Minneapolis-St. Paul, Newark, Philadelphia, Richmond, Rochester, San Diego Policy: Dallas-Ft. Worth
Ownership	A shift to ridesharing and on-demand travel will reduce car ownership.	11	Mention: Austin, Chicago, Cleveland, Dallas-Ft. Worth, Los Angeles, Milwaukee, Philadelphia, Pittsburgh, Raleigh, Richmond, Washington DC
Efficiency	AVs, and especially C/AVs will improve transportation system efficiency by reducing crashes, eliminating delays, and being able to reroute as needed.	10	Mention: Birmingham, Boston, Chicago, Denver, Memphis, Newark, Richmond, San Antonio, Seattle, St. Louis
Revenue	More fuel-efficient vehicles, including AVs, will reduce transportation revenue (e.g., gas taxes); need to implement new fees (e.g., road-use, congestion, VMT charges, etc.). Reduced parking will also reduce local revenue.	10	Mention: Birmingham, Buffalo, Charlotte, Dallas-Ft. Worth, Las Vegas, Memphis, Milwaukee, Philadelphia, San Antonio, St. Louis
Pilot projects	Pilot projects could expedite deployment of AVs; use pilot projects to deploy technology to meet regions' needs; partner with industry.	8	Mention: Birmingham, Buffalo, Chicago, Dallas-Ft. Worth, Portland, Salt Lake City Policy: Hartford, St. Louis
Emissions / fuel economy	If AVs increase congestion and trips, they could increase GHG emissions; alternatively, if AV are deployed as primarily electric vehicles they will reduce emissions.	7	Mention: Birmingham, Dallas-Ft. Worth, Milwaukee, Richmond, Rochester, San Diego, Virginia Beach
Productivity	Increased productivity will happen if commuting time is spent on activities other than driving.	7	Mention: Birmingham, Cleveland, Dallas-Ft. Worth, Indianapolis, New York, Rochester, Virginia Beach
Employment impacts	AVs will reduce jobs for taxi, rideshare, and transit drivers, and freight and deliveries. This is likely to disproportionately affect low-income workers.	7	Mention: Birmingham, Buffalo, Los Angeles, Philadelphia, Washington DC Policy: Pittsburgh, St. Louis
Multimodal transportation	AVs are one part of a multimodal transportation system; multimodal transportation systems maximize the efficiency of the whole transportation system; adapt streets to meet the needs of a multimodal transportation system.	6	Mention: Miami Policy: Buffalo, Chicago, Dallas-Ft. Worth, Philadelphia, St. Louis

Data-sharing	Data gathered by public agencies should be open access; public agencies should leverage transportation companies to provide data that can aid in the planning and analysis of the transportation network.	6	Mention: Buffalo Policy: Chicago, Dallas-Ft. Worth, Hartford, Philadelphia, Portland
Security and privacy	Need to protect privacy and build cybersecurity capacity at a regional level.	5	Mention: Atlanta, Buffalo, Rochester Policy: Philadelphia, San Antonio
Equitable communities	Benefits of AVs are likely to be limited to high-income earners; need to ensure that benefits of AVs and other new mobility options are spread to low-income and other disadvantaged or marginalized communities.	5	Mention: Birmingham, Policy: Chicago, Pittsburgh, Portland, St. Louis
Partnerships + collaborations	Build partnerships with private-sector service providers; collaborate with regional partners.	5	Policy: Detroit, Hartford, Pittsburgh, San Antonio, St. Louis
Government regulation	Regulations need to be developed; regulation should reflect the needs of urban areas.	5	Mention: Birmingham, Cleveland, Kansas City Policy: Chicago, Philadelphia
Reliability	AVs and C/AVs can improve transportation system reliability.	4	Mention: Chicago, Denver, Richmond, Virginia Beach
Interaction with human drivers	Concern over how AVs will interact with human-driven cars, particularly how this will affect roadway safety.	4	Mention: Detroit, Kansas City, Milwaukee, Washington DC
High costs	Mass deployment of AVs will be slowed by the high cost of vehicles and the high costs of infrastructure needed to support them.	3	Mention: Birmingham, Chicago, Rochester
Road maintenance	AVs require improved roadway/pavement conditions and may require more frequent maintenance.	3	Mention: Cleveland Policy: Detroit, Philadelphia
Mobility as a service (MaaS)	Ridesharing and other new mobility as part of "Mobility as a Service." Public agencies should work to coordinate public and private transportation services to make transportation more convenient.	3	Mention: Buffalo, Seattle Policy: Pittsburgh
Liability	AV liability is unclear.	1	Mention: Buffalo
Interoperability	Work with stakeholders to establish guidelines for compatibility and interoperability.	1	Policy: Hartford

A common challenge that emerged in the RTPs is the uncertainty surrounding the development, deployment, effects, and anticipated use cases of AVs. Many RTPs state that AVs could have positive or negative effects on a given issue. For example, many plans highlight uncertainty within the context of travel behavior and associated impacts, such as in Seattle, where "the rapid change in technology makes it hard to predict when new technologies will mature and become widespread, what the impacts will be on all aspects of transportation, such as travel behavior, land use, and parking" (PSRC, 2018). In one extreme, Tucson's PAG states that AVs and other major transportation trends "will have considerable impacts on regional development and the region's transportation system," and while these deserve "further exploration in terms of how it may upend current planning assumptions," this is "outside the scope of the current planning effort" (PAG, 2016). A couple MPOs, like Buffalo's GBNRTC, use the uncertainty of AVs as an opportunity to develop innovative methods: "given the particular uncertainty about the risks and impacts of AV, GBNRTC will continue developing a regional travel model that incorporates AV" (GBNRTC, 2018). Still others take more of a "wait and see" approach, such as Philadelphia, which plans to "monitor new technologies to gain understanding of potential applications to improve the safety, efficiency, and user experience of our transportation network" (DVRPC, 2017), or Denver, where "DRCOG and its planning partners will closely monitor technological advances (and legislative actions) related to connected vehicles and infrastructure and autonomous vehicles" (DRCOG, 2017). Like Denver, many MPOs have adopted broad policies to monitor the development of AV technology as a way to address uncertainty before the next full update of their RTP.

Safety

Safety is the most commonly cited issue. There is general agreement among the plans on the assumption that AVs will positively affect roadway safety by reducing the number of crashes on roads, a majority of which are caused by human error. Birmingham's RTP, for example, states that "dramatic improvements in safety are predicted with a high degree of certainty. A full third of all fatal crashes could be eliminated simply if all vehicles were equipped with basic CV features like forward-collision, lane-departure, and blind spot warning systems, as well as adaptive headlights" (RPCGB, 2019). Unanticipated safety concerns are also mentioned, as in the Boston RTP, which states that "advancements in connected and autonomous vehicle (CAV) technology have the potential to generate safety benefits, but this technology may also change travel patterns and influence traveler behavior in ways that introduce new concerns" (BRMPO, 2019). Safety is also addressed in relation to other road users: "Safe integration with people on foot and bike is one of the main remaining technical issues for C/AVs, and addressing those technical limitations will be important to Bike/Ped planning" (MMPO, 2019). A final safety issue is how AVs will interact with non-AV cars on the roads, such as Philadelphia's DVRPC, stating that "until AVs are operating on their own infrastructure, society may not see significant safety, congestion or other expected benefits" (DVRPC, 2017). These plans often claim that dedicated infrastructure for AVs might be a solution to addressing safety concerns of AVs. Safety is mentioned in a majority of plans, but there is significant variation in how different MPOs address safety.

Ridesharing, Mobility, and Ownership

Rideshare is the second most commonly cited issue, with a majority of mentions of rideshare being neutral. Dallas-Ft. Worth's RTP is perhaps the most positive about ridesharing, stating that

> if automated vehicles result in car-sharing or ridesharing, the number of cars on the roads could decrease, leaving more opportunity for bicyclists and pedestrians. Some parking spaces could be developed, increasing density and promoting sustainable public transportation options. (NCTCOG, 2018).

However, a majority of plans simply identify ridesharing as a major transportation trend that will likely grow as AVs are deployed. The issue of ridesharing is closely related to two other top mentioned issues, mobility and accessibility (15 mentions) and vehicle ownership (11 mentions). The reason for this is because low-cost rideshare achieved with AV technology could drastically increase mobility options for multiple demographics (e.g., senior citizens, disabled, youth, etc.). Likewise, a transition to ridesharing could lower vehicle ownership. As summarized in the Buffalo RTP, this new model of transportation is increasingly "built on access, not on ownership" (GBNRTC, 2018).

Land Use, Transit, and Travel Behavior

The next most commonly mentioned issues are land use and parking, public transportation, and travel demand and behavior, which are highly interrelated. Birmingham's RTP summarizes this interconnectedness well:

> More efficient land use patterns may also be encouraged. AVs will require much less space to park, as an AV can simply drive itself to its owner's home and will not require a parking space within walking distance of the owner's destination. With less space devoted to parking, space can be utilized more productively. However, AVs may just as easily facilitate sprawl. By reducing the cost, time and effort to drive, advanced vehicles could encourage choices to live further from urban centers. Moreover, by granting mobility to previously immobile groups such as the elderly, teenagers, and people with low incomes, latent travel demand of these groups would be immediately realized, possibly increasing vehicle miles traveled … (RPCGB, 2019)

Like this one, a majority of RTPs mention each of these in terms of potentially positive and negative impacts, again highlighting the uncertainty of these impacts.

Of these issues, mentions of transit tends to highlight the negative impacts from AVs, with a potential to draw riders away from transit and reduce resources for this vital service. However, several RTPs also mention the potential benefits to transit, such as in Memphis where "Many forecasters see shared mobility companies taking ridership from transit agencies—but the others see potential in automated buses or vans" (MMPO, 2019). The Birmingham RTP elaborates on the potential benefits to transit:

> Possible benefits include more efficient and frequent transit service … By removing the operator, AVs remove this incentive and permit smaller, fuller vehicles running at higher frequencies, which attracts more riders. Moreover, as labor is commonly the largest operational expense for transit, AVs could free up funds for other needed investments. (RPCGB, 2019)

Infrastructure

Infrastructure is another major issue, mentioned in 15 RTPs, often discussed in conjunction with roadway capacity (14 mentions). As with other issues, a majority of RTPs highlight the uncertainty in the types of infrastructure needed for AVs, with MPOs like Milwaukee stating that "[i]t is difficult to predict how infrastructure investment should be adjusted to adapt to a future in which some or all cars are autonomous" (SEWRPC, 2016). There is also a common theme that as AVs are deployed they will decrease the need to invest in new highway infrastructure, as mentioned in the St. Louis RTP: "the additional safety of AVs and their ability to travel closer to one another through connectivity suggests that they may be able to make more efficient use of roadways, essentially boosting capacity" (EWGCOG, 2019). Many of the RTPs discuss infrastructure within the context of connected vehicles and not strictly AVs. As a result, there are several mentions of increasing communications infrastructure, in additional to more traditional roadway infrastructure. In some cases, MPOs suggest that "[m]ass deployment will be impeded by high costs, both for the vehicles and for the infrastructure required to support them" (RPCGB, 2019).

Congestion and Road Capacity

The final two top issues are congestion (14 mentions) and road capacity (14 mentions), which are usually mentioned together, as they are highly related. Increased road capacity achieved by more efficient use of existing roads can alleviate congestion, although increased mobility, zero occupant vehicles, and new trips generated by changes in travel behavior could negate any congestion benefits. On these issues, uncertainty is high. As the Richmond RTP states,

> The adoption of autonomous and connected vehicles technologies will have significant impacts on travel behavior, safety, car-ownership, infrastructure, land-use, and development patterns … autonomous vehicles could increase vehicle miles traveled (VMT) by lowering the time-costs of travel and parking and by giving increased mobility to children, the elderly, the blind, and others restricted from operating vehicles. On the other hand, driverless cars could reduce VMT by enabling more car-sharing, better transit … (RRTPO, 2016)

EMERGING POLICIES IN RTPs

A total of 12 RTPs have policies regarding AVs (as of 2019). The most common policy areas in 2018 included infrastructure, data sharing, multimodal transportation, public transit, safety, and equitable communities. These remain the most common policy areas in 2019, but land use and parking, partnerships and collaborations and pilot projects emerge as three new policy areas.

Infrastructure

The most common policy issue is infrastructure development and maintenance. A majority of the plans include more broad policies on maintaining and upgrading existing infrastructure in a way that will meet the needs of AVs (AAMPO, 2019; CRCOG, 2019; EWGCOG, 2019; NJTPA, 2017; SPC, 2019). In St. Louis, this includes continuing to "invest in the regional ITS system by making use of the latest technology and Big Data capabilities to improve management of the transportation system and prepare the region for connected and autonomous vehicle technology" (EWGCOG, 2019). These investments are seen as a way to catalyze the adoption and use of AVs and other emerging transportation technologies, exemplified by the straightforward policy in Chicago to "identify investments that could catalyze emerging technologies" (CMAP, 2018). Chief among these is building a robust communications network to facilitate C/AV adoption. Dallas-Ft. Worth, Philadelphia, Hartford, and San Antonio all have similar policies on building more robust communication infrastructure, which in the case of San Antonio is specifically to "incorporate fiber technology wherever" (AAMPO, 2019). Philadelphia also calls out upgrading traffic signals and installing roadway warning devices as a way to be prepared for AVs and other emerging technologies. In Buffalo, the infrastructure policy calls for the development of smart corridors, or smartly enhanced multimodal arterials (SEMAs), which require new roadway configurations, transit infrastructure, curb space enhancements, and connected infrastructure, which will help prepare the city for AVs (GBNRTC, 2018).

In addition to policies on new infrastructure investment, MPOs are also finding it important to maintain existing infrastructure in a way that will be compatible with AV testing and deployment. Las Vegas, Dallas-Ft. Worth, and Philadelphia all have policies to maintain roadways at a higher standard than is currently maintained. In Las Vegas and Philadelphia, this includes the goal to "maximize pavement quality, making lanes narrower, and providing clear and obvious lane markings and navigation aids" (RTCSNV, 2017). The Dallas-Ft. Worth policy links maintenance to the provision of new infrastructure, stating that

> maintaining existing roadways at a level that supports the effective and safe operation of automated (and human driven) vehicles will be accomplished before investing in the construction of new roadways that add to the inventory of roadways the region must maintain. (NCTCOG, 2018)

Related to infrastructure, Dallas-Ft. Worth also has a policy to promote more efficient use of existing roadways and to explore options for using AVs and demand management tools "as an alternative to building additional lanes to increase roadway capacity" (NCTCOG, 2018).

Safety
Safety is the second most common policy area for RTPs. Chicago, Newark, San Antonio, and Detroit each have general policies aimed at improving travel safety by employing new and emerging technologies in the short term (e.g., crash avoidance, lane keeping, etc.), as well as AVs and connected vehicles (AAMPO, 2019; CMAP, 2018; NJTPA, 2017; SEMCOG, 2019). The Detroit policy on safety is unique in that it highlights the aging population in its region and the need to "Integrate connected and automated technology and other advanced features on roadways so that persons with limited mobility can safely travel, regardless of mode" (SEMCOG, 2019). In Pittsburgh, the RTP states that it must be "proactive in setting regulatory standards and ensuring that safety and best practices are being followed as public transit, C/AVs, ridesharing, and other technologies change our developed landscape" (SPC, 2019).

Data-Sharing
Data-sharing, along with policies for privacy and security, make data a key element of policy-oriented RTPs, and it is an issue not mentioned at all in those RTPs without policies. These policies respond to the need to not only collect data and the capacity necessary to do so, but for the need for analyzing and using the data. Dallas-Ft Worth has a total of three policies regarding data, which include requiring that

> transportation agencies in the region will make data about their systems accessible using open data best practices in order to support automated vehicle operations and optimize the operation of travel navigation, mobility-as-a-service payment, and other transportation services in use today and in the future,

prioritizing two-way data-sharing agreements, and leveraging data-sharing agreements before investing in new hardware/infrastructure (NCTCOG, 2018). In Philadelphia, the policy is to "provide open access to data and use it to promote more efficient transportation," as well as to foster "agreements among private transportation operators that ensure transportation data is open and freely available while protecting competitive and proprietary information and personal privacy" (DVRPC, 2017). The Chicago policy makes "the collection, sharing, and analysis of public and private sector transportation data a regional priority" (CMAP, 2018), while also outlining roles for both the public and private sector:

> the public sector should identify ways to leverage provision of more detailed data and analysis to private companies while carefully protecting riders' privacy. Private sector partners should share data that aids planning for transit, the road network and emerging mobility services. (CMAP, 2018)

Data collecting, sharing, analysis, and ensuring the security of private information continues to be raised as a concern in literature on AVs and will need to continue to be addressed. These early policies aim to leverage the use of new data in transportation planning and to make public data available to the public, continuing a public-sector trend to be more open and transparent.

Multimodal Transportation

A key policy area is the development of multimodal transportation systems of which AVs are a part. In Portland, the policy is to provide transportation choices and to "use emerging technology to improve transit service, provide shared travel options throughout the region, and support transit, bicycling, and walking" (Metro, 2018). In Buffalo, they are advancing the creation of mobility hubs and smartly enhanced multi-modal arterials (SEMSs), which transform arterial streets from single-use, automobile-oriented streets into multimodal corridors (GBNRTC, 2018). Chicago has a similar policy to "adapt the street and sidewalk to emerging developments in transportation" (CMAP, 2018). As in Chicago, the Buffalo policy promotes flexible curb space that can support the use of shared AVs. In Dallas-Ft Worth, one of the focal points is on ridesharing with

> the region [that] will support efforts to ameliorate the impact of increased demand for mobility as a result of [AVs] by supporting efforts to increase average vehicle occupancy by transportation network companies and other transportation suppliers and through demand management tools … (NCTCOG, 2018)

Public Transit

The threat of AVs drawing riders and resources away from public transit weighs in as a significant concern. In Philadelphia, the goal is to make transit more competitive with signal priority, off-board fare payment, dedicated bus lanes, and to use smart and automated technology to make the transit system more efficient (DVRPC, 2017). In Chicago, the policy is to "invest in and protect transit's core strengths," which include working with "communities to establish policies for AVs, TNCs, and other emerging technologies that support and complement the public transit system" (CMAP, 2018). Additionally, there is recognition in the Chicago RTP that "shared mobility and [AV] technologies have the potential to provide more frequent and direct service in low-income neighborhoods, improving connections to jobs that may currently require long transit trips or connecting multiple modes" (CMAP, 2018). In Buffalo, a similar policy to enhance regional equity aims to support TNCs and "and eventually autonomous circulators—to improve connectivity from neighborhoods to services and shopping areas, as well as connections among the smaller cities" (GBNRTC, 2018) within the MPO. In Portland, Metro has identified the need to "fund technology pilot projects to test new approaches to connecting people to transit, promoting shared and active trips, and providing more equitable transportation options" (Metro, 2018).

Land Use and Parking

Land use and parking policies only accounted for one of the seven initial MPOs sampled in 2018. However, four of the five plans adopted in 2019 also include land use and parking policies, now making it a top policy area. Chicago includes establishing "pricing and regulatory frameworks that positively shape the impacts of autonomous vehicles and other technologies on infrastructure and land use" (CMAP, 2018). The Hartford policy is to "[w]ork with stakeholders to focus new and emerging technology investments and pilots near TOD zones to enhance first/last mile connectivity to transit and high-density, mixed uses" (CRCOG, 2019). The remaining three policies focus more on parking than broader land use issues. Detroit and Pittsburgh policies emphasize curb space management and the development of standards for loading zones and parking (SEMCOG, 2019; SPC, 2019). Lastly, the St. Louis policy ties land use and parking together with providing a multimodal transportation system in its aim at supporting "urban vitality by providing an optimal mix of space for on-street parking, shared use options, transit services, and green space, leveraging emerging transportation technologies" (EWGCOG, 2019).

Equitable Communities

A total of four plans have policies in the area of "equitable communities." The Chicago MPO has a policy to "ensure that emerging technologies support inclusive growth," which addresses the potential for AVs to be "cost prohibitive for lower income households, people with disability and municipalities with fewer fiscal resources" (CMAP, 2018). In Portland's RTP, one of their four policies for emerging technologies centers on equity, which is to "[m]ake emerging technology accessible, available, and affordable to all, and use technology to create more equitable communities" (Metro, 2018). The concept of inclusive growth in the Chicago RTP mirrors the Portland plan, both of which aim to ensure that low-income households, people with disabilities, and economically disconnected communities are not further disadvantaged. As the Chicago RTP policy argues, "making inclusive growth a cornerstone from the very outset of policy development for emerging technologies can help leverage them to reduce rather than increase inequities of access to transportation" (CMAP, 2018).

Partnerships and Collaborations

The final frequent policy area is new to the five plans adopted in 2019 and did not appear in any of the earlier plans and emphasizes the need for the MPO to build partnerships and collaborate with public and private sector entities. The policies do range in their scope. More broad policies include those such as Detroit's which is to "[e]xpand funding to create innovative public private partnerships with New Mobility services that are both being developed around a future Connected and Autonomous Vehicle operating environment and new mobility providers" (SEMCOG, 2019). The policies in Hartford, Pittsburgh, and San Antonio emphasize collaborating with regional partners on a range of issues, from interoperability (CRCOG, 2019), land use requirements, and regional deployment (SPC, 2019), and data security (AAMPO, 2019). Hartford also has a policy to "[w]ork with stakeholders to incentivize inter-agency coordination and deployment of new and emerging technologies by awarding points to agencies that collaborate on pilots and deployments during funding distribution processes" (CRCOG, 2019).

DISCUSSION

The top issues among RTPs in both 2018 and 2019 (safety, ridesharing, land use and parking, public transportation, travel demand and behavior, infrastructure, congestion, mobility and accessibility, road capacity, and ownership) are also those issues most often cited in literature and popular media. There are a range of opportunities and risks associated with AVs on each issue discussed that are likely to play out differently in different regions.

The plans analyzed in this paper tend to assume positive safety or congestion benefits. On the issue of safety, only three of the RTPs that mention AVs discuss potential negative impacts on safety, while 23 mention positive benefits. While it is possible that AVs will improve roadway safety, serious questions remain about the safety impacts on pedestrians and bicyclists, or around the safety of mixing AVs and human drivers. AVs, as Stilgoe (2018b) notes, are currently presented as a technological solution to the challenge of safety that policymakers have been unable to prioritize. This perspective is highlighted by rising pedestrian and cyclist deaths in recent years (Stachura, 2019). MPOs can play an important role in the processes of social learning (Stilgoe, 2018a) that must take place around AVs. This, however, requires MPOs to more rigorously consider the impacts of AVs and consider system-wide solutions to safety, not technological fixes. The RTPs with policies show an early indication of moving in this direction—of more thoughtfully assessing the positive and negative impacts and proposing policies that may result in more positive outcomes than negative ones. This, however, still leaves 40 RTPs that inadequately assess the range of impacts that AVs will have or do not even mention AVs.

The need for more detailed consideration and analysis of the risks and opportunities that AVs present highlights the reality that for the foreseeable future, MPOs must plan for uncertainty—not just about AVs, but also about transportation technology more broadly, infrastructure needs, and funding—in a more direct way. Much of what MPOs do already revolved around uncertainty—about future population and economic growth trends—but they have developed forecasting and modeling methods to adequately plan for these levels and types of uncertainty. The uncertainty inherent in AVs is arguably more complex than anything that MPOs have had to address in the past, due to the range of impacts and the uncertainty of what those impacts will be—from VMT, to congestion, to land use, parking requirements, safety, and others—is greater. This is likely why many MPOs have a "wait and see" approach—so that they can better understand the impacts before planning for a new technology. Yet, as science and technology studies scholars have shown, as technologies are deployed and become ubiquitous, it becomes increasingly difficult to proactively and responsibly manage them. Transportation planners, then, would be well advised to develop the capacities and tools to manage AVs and other emerging technologies to meet stated public policy goals, while such management is still possible (Collingridge, 1980).

In contrast to the "wait and see" approach, other MPOs have used the uncertainty of AVs to be more proactive, to develop new and innovative methods for managing uncertainty and to develop policies in a way that fosters innovation, facilitates the deployment of AVs, while also attempting to minimize the risks as we understand them now. In Buffalo, GBNRTC has developed a regional transportation model that considers variables like AV penetration, vehicle availability, peoples' willingness to spend more time and go farther distances, costs, and the effects of AVs on person miles and hours traveled and road capacity. In Portland, Metro is developing a regional activity-based model that "is analytically positioned to overcome the methodological shortcomings of the current trip-based model and can be adapted to explicitly represent evolving travel behavior (e.g., travel via Uber/Lyft) or new near-horizon advances in technology (e.g., connected and automated vehicles)" (Metro, 2018). In Tucson, while their uncertainty has prevented them from even a cursory discussion of AVs and their impacts, it has prompted them to develop a scenario-based planning model. In Phoenix, MAG "is working on developing tools and methods that will facilitate planning efforts addressing these changes in the way transportation is provided" (MAG, 2017), which includes an activity-based travel demand forecasting model and an agent-based freight model. And in Seattle, PSRC "will continue to enhance the regional travel model's ability to analyze the effects of new technology on travel" (PSRC, 2018). Each of these demonstrate that MPOs recognize the future of transportation requires them to cope with greater levels of uncertainty and to develop new tools to plan under these conditions.

A handful of MPOs are taking these proactive steps in efforts to reduce the risks associated with planning for an uncertain transportation future. Given the uncertainty, MPOs must still plan and deploy new infrastructure, maintain the infrastructure cities already have, and find ways to reduce congestion, improve air quality, and address immediate planning issues that AVs may or may not help with in the future. MPOs are wary to spent limited resources on unproven infrastructure for AVs, or even invest in new roads and highways when they might not be necessary even 10 years from now. This makes RTPs like that in Dallas-Ft. Worth stand out for exploring the use of AV technology and other advanced travel demand management strategies before building additional roadways to increase capacity. Policies such as this allow the MPO to actively develop infrastructure in a way that aligns with their broader transportation goals, allows the development of AVs, and will not adversely affect the long-term operation of the transportation network. Reducing risk requires MPOs to not only monitor and assess AV technology, but to explore in real-time, how AVs and emerging transportation technology can help them meet their goals around safety, congestion, accessibility, etc.—goals which are a local, contextual policy decision. MPOs and other urban planning institutions play a critical role to ensure that AVs are deployed in ways that align with public values and policy goals.

Even with these innovations in modeling, MPOs still need to go further to build an adaptive capacity to be able to respond to emerging technologies responsibly. The framework of anticipatory governance is one such model that MPOs can use to build such a capacity (Boyd and Juhola, 2015; Cohen et al., 2018; Fuerth, 2009; Guston, 2014; Quay, 2010; Stilgoe et al., 2013; Wiek et al., 2013). And in fact, those MPOs that are the most innovative already have elements of this framework that can be strengthened to diversify the toolkits that MPOs and transportation planners have at their disposal.

Anticipatory governance is comprised of four components. Foresight and futures analysis is the first, which develops and analyzes possible future scenarios (Fuerth, 2009; Guston, 2014; Quay, 2010). Anticipatory governance recognizes the limitations of traditional prediction and forecasting tools (such as those used widely in regional transportation planning). Similarly, many urban planners recognize the limits of transportation models (Batty, 2015; Orrell, 2014; Walker, 2014) and the emergence of new scenario planning tools and other models developed by MPOs are a step towards building foresight capacity. The development of flexible planning mechanisms, or responsiveness (Cohen et al., 2018; Quay, 2010) would allow MPOs to adjust policies more quickly based on new information than is usually the case today. This responsiveness would be based on processes of monitoring and learning built into the planning process (Quay, 2010), in which MPOs would learn through experimentation about how AVs and other emerging technologies are affecting their regions' transportation networks. The last component of anticipatory governance is public engagement (Cohen et al., 2018; Guston, 2014; Stilgoe et al., 2013).

The types of policies thus far adopted by MPOs are incremental and flexible enough in their scope to adapt to changes in AV technology and deployment. And the MPO in Buffalo has also developed an adaptive planning framework, that

> promotes flexible decision-making that can be adjusted in the face of uncertainties as outcomes from projects and other efforts become better understood. It is not a "trial and error" process, but rather emphasizes learning while doing. Adaptive planning allows for pilots and experiments to learn effects, gather data, and adapt. To be successful requires a willingness to be agile, to experiment, fail and learn. (GBNRTC, 2018)

This new planning framework incorporates multiple elements of anticipatory governance to help the Buffalo region respond more quickly to the development of AVs and other emerging technologies.

One key area that is still missing, however, is public engagement in the management of emerging technologies (Cohen et al., 2018; CSPO, 2019; Worthington et al., 2012). This element is critical to advancing AVs in a way that addresses issues of equity and mobility justice (and others). Equity, accessibility, and other such goals are often promoted by industry, but ultimately the realization of these is ultimately a planning and policy decision. It is thus, a reason for optimism that several of the RTP plans do have policies to address issues of equity and accessibility. MPOs need to engage stakeholders (e.g., the public, industry, etc.) and make issues such as equity a priority (or whatever other public goals are identified). Left to market forces alone, it is likely that these potential benefits will go unrealized and could even worsen.

Elements of anticipatory governance are also seen in national organizations and industry recommendations for how cities and regions should plan for AVs. A 2019 Deloitte report recommends five regulatory principles for emerging technologies: adaptive regulation, regulatory sandboxes for testing, outcome-based regulation, risk-weighted regulation that is data driven, and collaborative regulation (Pankratz et al., 2018). The Association of Metropolitan Planning Organizations' (AMPO) National Framework for Regional Vehicle Connectivity and Automation Planning provides guidance to MPOs on what they can do now to plan for AVs. AMPO recommends engaging and collaborating with key stakeholders and the public; adopting key policies; developing more robust modeling methods; and ensuring that MPOs have institutional readiness for AVs (AMPO, 2019). The policies AMPO recommends mirror many of those discussed in this paper and include: "developing a vision and goals for the desired future of transportation with vehicle connectivity and automation deployed to help understand how it can help meet regional transportation needs and goals," foster innovation, "encourage shared use and other strategies that will mitigate potential increases in transportation demand and vehicle miles traveled," build partnerships, and "support deployment scenarios that do not systematically disadvantage any transportation system users" (AMPO, 2019). These regulatory approaches align well within the framework of anticipatory governance.

In addition to the four elements of anticipatory governance, there is need for MPOs and planning institutions to further develop partnerships and collaborations. Companies like Uber and Lyft have recently been shown to increase congestion (Hawkins, 2019) and reduce public transit use (Graehler et al., 2019). Left to operate on their own, AV ridesharing may not result in many of the benefits the companies claim it will. Partnering with AV companies now and developing collaborations will allow MPOs and cities to experiment with how AVs can actually help them meet their transportation goals. A vital part of this is the need to make monitoring and learning a central element of these. Without it, there is no way to understand if and how AVs are helping solve the complex problems around safety, congestion, accessibility, etc. To this end, it is a positive trend that several of the RTPs adopted in 2019 have developed policies around partnerships and collaborations and on deploying pilot projects in their regions. For example, Hartford's policy is to support an "automated vehicle pilot, that focuses on first/last mile connections, university areas, large employers, or in areas with parking limitations" (CRCOG, 2019), while St. Louis will "encourage pilot initiatives to provide better first-mile /last-mile connections to fixed route transit, such as autonomous shuttles, and partnerships with private sector service providers" (EWGCOG, 2019). Thus far, however, it seems that the ability to learn from pilot projects and to revise policy, or even develop more robust policy as a result of lessons learned is a missing component. But MPOs and planning institutions must build this capacity, as it is a key element of anticipatory governance and planning for AVs and emerging technologies that present cities and regions with an uncertain future.

CONCLUSION

Currently, a total of 41 of the largest MPOs include AVs in their RTPs, with 12 of these MPOs developing policies to guide the development and deployment of AVs, to foster innovation, and to ensure that this emerging technology addresses the concerns that many cities have around public transit and multimodal transportation, around equity, congestion, and other key issues. This, however, may be too little progress for MPOs as they plan for future transportation systems that will have varying levels of AVs operating. Given the four-year timeframe of a RTP, all of the plans analyzed here will likely be updated by 2023–2024, many before then. But only half of plans updated between 2018 and 2019 incorporated policies for AVs. If this trend continues, it could take up to two updates (eight years) for AVs to be fully considered in RTPs, by which time most regions will see significant deployments of AVs, which could be substantial. If this is the case, it means that transportation agencies will be reacting to the emergence of AVs rather than being proactive and actually planning for it in advance.

AVs and other emerging mobility technologies have the potential to transform the ways in which people and things move around the city. How they do so will be in large part determined by how policy and planning institutions assess and respond. In order to adequately plan infrastructure in a rapidly evolving landscape, urban governments and communities must learn how to anticipate the potential impacts of emerging technologies (Guston, 2014; Sarewitz, 2011) and manage them based on community needs and values. This is not only a technological challenge of applying new technologies, but also a social and institutional challenge how to collectively govern new technologies for shared goals. MPOs need to develop more flexible planning approaches that allow them to adapt and change direction more quickly as AVs are deployed and to develop a broad-based capacity for anticipatory governance—i.e., a distributed capacity of lay and expert stakeholders to collectively learn and interact in order to manage emerging technologies while such management is still possible (Barben et al., 2018). A small number of MPOs and their respective RTPs analyzed in this paper show signs that this is the direction they are moving. The use of scenario planning, Buffalo's adaptive planning framework, and policies that can be broadly interpreted and easily changed in the face of new information are key to this anticipatory capacity. As evidenced in RTPs, only a small number of MPOs are building this anticipatory governance capacity. However, not all aspects of MPO planning activities are reflected in RTPs, which has been the focus of this paper, and additional research can help uncover how MPOs are adapting and learning to plan for emerging transportation technologies, the effective governance of which will have a significant impact on community well-being, human health, economic development, and sustainability.

REFERENCES

AAMPO. "Mobility 2045: Moving People, Connecting Places" (San Antonio, TX: Alamo Area Metropolitan Planning Organization, 2019) http://www.alamoareampo.org/Plans/MTP/docs/Mobility2045/Mobility2045_document.pdf, Accessed: November 24, 2019.

AMPO. "National Framework for Regional Vehicle Connectivity and Automation Planning" (2019), http://www.ampo.org/wp-content/uploads/2019/04/2019-AMPO-Framework-11.pdf, Accessed: October 15, 2019.

S. A. Bagloee, M. Tavana, M. Asadi, and T. Oliver, "Autonomous Vehicles: Challenges, Opportunities, and Future Implications for Transportation Policies," Journal of Modern Transportation 24: 4 (2016) 284–303. https://doi.org/10.1007/s40534-016-0117-3

F. J. Bahamonde-Birke, B. Kickhöfer, D. Heinrichs, and T. Kuhnimhof. "A Systemic View on Autonomous Vehicles: Policy Aspects for a Sustainable Transportation Planning," DisP – The Planning Review 54:3 (2018) 12–25.

D. Barben, E. Fisher, C. Selin, and D. H. Guston, "Anticipatory Governance of Nanotechnology: Foresight, Engagement, and Integration," in E. J. Hackett, O. Amsterdamska, M. Lynch, and J. Wajcman eds., The Handbook of Science and Technology Studies (Cambridge, MA: The MIT Press, 2018).

M. Batty, "Models Again: Their Role in Planning and Prediction," Environment and Planning B: Planning and Design 42: 2 (2015) 191–194. https://doi.org/10.1068/b4202ed

L. T. Bergmann, L. Schlicht, C. Meixner, P. König, G. Pipa, S. Boshammer, and A. Stephan. "Autonomous Vehicles Require Socio-Political Acceptance—An Empirical and Philosophical Perspective on the Problem of Moral Decision Making," Frontiers in Behavioral Neuroscience 12 (February 2018) 1-12. https://doi.org/10.3389/fnbeh.2018.00031.

Bloomberg Philanthropies. "Autonomous Vehicles in Cities," (2019) https://avsincities.bloomberg.org, Accessed: November 22, 2019. 196

E. Boyd and S. Juhola, "Adaptive Climate Change Governance for Urban Resilience," Urban Studies 52: 7 (2015) 1234–1264. https://doi.org/10.1177/0042098014527483

BRMPO. "Destination 2040," (Boston, MA: Boston Region Metropolitan Planning Organization, 2019), https://www.bostonmpo.org/data/pdf/plans/LRTP/destination/Destination-2040-LRTP-20191030.pdf, Accessed: November 24, 2019.

A. Brumage, "The Uneven Rise of Autonomous Vehicles and the Isolation of Rural America," TheSciTechLawyer 14: 4 (2018).

D. G. Chatman and M. E. Moran. "Autonomous Vehicles in the United States: Understanding Why and How Cities and Regions Are Responding," (2019) Berkeley, CA. https://doi.org/10.7922/G2CZ35DZ

J. Claybrook and S. Kildare, "Autonomous Vehicles: No Driver … No Regulation?" Science 361:6397 (2018) 36–37. https://doi.org/10.1126/science.aau2715

R. R. Clewlow, "New Research on How Ride-Hailing Impacts Travel Behavior," Planetizen (October 11, 2017), www.planetizen.com/features/95227-new-research-how-ride-hailing-impacts-travel-behavior, Accessed Feb. 18, 2020.

CMAP, "On To 2050 Comprehensive Regional Plan," (Chicago, IL: Chicago Metropolitan Agency for Planning, 2018) https://www.cmap.illinois.gov/documents/10180/905585/ON+TO+2050+Comprehensive+Regional+Plan+FINAL.pdf/dfe78ce3-8601-1b1d-a0e9-77893a2a0b2a, Accessed: Sept. 17, 2018.

T. Cohen, J. Stilgoe, and C. Cavoli, "Reframing the Governance of Automotive Automation: Insights from UK Stakeholder Workshops," Journal of Responsible Innovation 5: 3 (2018)

257–279. https://doi.org/10.1080/23299460.2018.1495030
D. Collingridge, The Social Control of Technology (New York: St. Martin's Press, 1980).
CRCOG, "Connect 2045: Long Range Transportation Plan for the Metro-Hartford Capitol Region" (Hartford, CT: Capitol Region Council of Governments, 2019) https://crcogconnect2045.com/wp-content/uploads/2019/04/CRCOG-MTP-2019update_Full-Report.pdf, Accessed: November 24, 2019.
CSPO, "Our Driverless Futures: Community Forums on Automated Mobility" (Washington, DC: Consortium for Science, Policy and Outcomes [CSPO], 2019), https://cspo.org/research/driverless-vehicles/, Accessed October 19, 2019.
F. Cugurullo, R. A. Acheampong, M. Gueriau, and I. Dusparic, "The Transition to Autonomous Cars, The Redesign of Cities and the Future of Urban Sustainability, Urban Geography (2020) https://doi.org/10.1080/02723638.2020.1746096 Accessed November 3, 2020.
C. Curtis, S. McLeod, J. Hultén, F. Pettersson-Lofstedt, A. Paulsson, and C. Hedegaard Sørensen, "Knowledge for Policy-Making in Times of Uncertainty: The Case of Autonomous Vehicle Model Results," Transport Reviews (2020) https://doi.org/10.1080/01441647.2020.1857885
S. Dennis, A. Paz, and T. Yigitcanlar, "Perceptions and Attitudes Towards the Deployment of Autonomous and Connected Vehicles: Insights from Las Vegas, Nevada," Journal of Urban Technology (2021) https://doi.org/10.1080/10630732.2021.1879606 Accessed March 6, 2021.
R. Dowling and P. McGuirk, "Autonomous Vehicle Experiments and the City," Urban Geography (2020) https://doi.org/10.1080/02723638.2020.1866392 Accessed January 1, 2021.
DRCOG, "2040 Metro Vision Regional Transportation Plan" (Denver, CO: Denver Regional Council of Governments, 2017) https://drcog.org/sites/drcog/files/resources/FINAL20-20204020MVRTP20w20APPENDICES20-20April202017.pdf Accessed: Sept. 24, 2018.
F. Duarte and C. Ratti, "The Impact of Autonomous Vehicles on Cities: A Review," Journal of Urban Technology 25: 4 (2018) 3–18. https://doi.org/10.1080/10630732.2018.1493883
DVRPC, "Connections 2045: Plan for Greater Philadelphia" (Philadelphia, PA: Delaware Valley Regional Planning Commission, 2017) www.dvrpc.org/Reports/17039.pdf Accessed December 19, 2018.
EWGCOG, "Connected 2045: Long-Range Transportation Plan for the St. Louis Region" (St. Louis, MO: East West Gateway Council of Governments, 2019) www.ewgateway.org/wp-content/uploads/2019/08/Connected2045-FinalDraft-082819.pdf Accessed November 24, 2019.
D. J. Fagnant and K. Kockelman, "Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations," Transportation Research Part A: Policy and Practice 77 (2015) 167–181. https://doi.org/10.1016/j.tra.2015.04.003
F. Favarò, S. Eurich, and N. Nader, "Autonomous Vehicles' Disengagements: Trends, Triggers, and Regulatory Limitations," Accident Analysis and Prevention 110 (2018) 136–148. https://doi.org/10.1016/j.aap.2017.11.001
Federal Transit Administration, "Metropolitan Transportation Plan (MTP)" (2016) www.transit.dot.gov/regulations-and-guidance/transportation-planning/metropolitan-transportation-plan-mtp Accessed December 9, 2018.
Ford. "Looking Further: Ford Will Have a Fully Autonomous Vehicle in Operation by 2021," (2019) http://ophelia.sdsu.edu:8080/ford/09-30-2019/innovation/autonomous-2021.html Accessed December 19, 2019.
Y. Freemark, A. Hudson, and J. Zhao, "Are Cities Prepared for Autonomous Vehicles?" Journal of the American Planning Association 85: 2 (2019) 133–151.

https://doi.org/10.1080/01944363.2019.1603760
Y. Freemark, A. Hudson, and J. Zhao, "Policies for Autonomy: How American Cities Envision Regulating Automated Vehicles," Urban Science 4: 4 (2020) 55. https://doi.org/10.3390/urbansci4040055
L. S. Fuerth, "Foresight and Anticipatory Governance," Foresight 11: 4 (2009) 14–32. https://doi.org/10.1108/14636680910982412
GBNRTC, "Moving Forward 2050: A Regional Transportation Plan for Buffalo Niagara" (Buffalo, NY: Greater Buffalo Niagara Regional Transportation Council, 2018) www.gbnrtc.org/movingforward2050 Accessed December 18, 2018.
M. A. Geistfeld, "The Regulatory Sweet Spot for Autonomous Vehicles," Wake Forest Law Review 53 (2018) 337–364.
M. Graehler, R. A. Mucci, and G. D. Erhardt, 'Understanding the Recent Transit Ridership Decline in Major US Cities: Service Cuts or Emerging Modes?' in 98th Annual Meeting of the Transportation Research Board (2019).
R. Grahn, S. Caldwell, and C. Hendrickson, "Recommended Policies for the 21st Century Trends in US Mobility" (Pittsburgh, PA: Carnegie Mellon University, 2019) www.cmu.edu/energy/education-outreach/policymaker-outreach/documents/2019-recommended-policies-for-the-21st-century-trends-in-mobility.pdf Accessed February 18, 2020.
E. Guerra, "When Autonomous Cars Take to the Road," Planning (May 2015) 36–38
E. Guerra, "Planning for Cars That Drive Themselves," Journal of Planning Education and Research 36: 2 (2016) 210–224. https://doi.org/10.1177/0739456X15613591
D. H. Guston, "Understanding 'Anticipatory Governance,'" Social Studies of Science 44: 2 (2014) 218–242. https://doi.org/10.1177/0306312713508669
A. M. Haque and C. Brakewood, "A Synthesis and Comparison of American Automated Shuttle Pilot Projects," Case Studies on Transport Policy 8: 3 (2020) 928–937. https://doi.org/10.1016/j.cstp.2020.05.005
M. Harb, A. Stathopoulos, Y. Shiftan, and J. L. Walker, "What Do We (Not) Know About Our Future with Automated Vehicles?," Transportation Research Part C: Emerging Technologies (2021) https://doi.org/10.1016/j.trc.2020.102948 Accessed February 17, 2021.
A. J. Hawkins, "Uber and Lyft Finally Admit They're Making Traffic Congestion Worse in Cities," The Verge (August 6, 2019) www.theverge.com/2019/8/6/20756945/uber-lyft-tnc-vmt-traffic-congestion-study-fehr-peers Accessed August 30, 2019.
J. Himmelreich, "Never Mind the Trolley: The Ethics of Autonomous Vehicles in Mundane Situations," Ethical Theory and Moral Practice 21: 3 (2018) 669–684. https://doi.org/10.1007/s10677-018-9896-4
L. M. Hulse, H. Xie, and E. R. Galea, "Perceptions of Autonomous Vehicles: Relationships with Road Users, Risk, Gender and Age," Safety Science 102 (2018) 1–13. https://doi.org/10.1016/j.ssci.2017.10.001
S. Karnouskos and F. Kerschbaum, "Privacy and Integrity Considerations in Hyperconnected Autonomous Vehicles," Proceedings of the IEEE, 106: 1 (2018) 160–170. https://doi.org/10.1109/JPROC.2017.2725339
E. Kassens-Noor, D. Dake, T. Decaminada, Z. Kotval-K, T. Qu, M. Wilson, and B. Pentland, "Sociomobility of the 21st Century: Autonomous Vehicles, Planning, and the Future City," Transport Policy 99 (2020a) 329–335. https://doi.org/10.1016/j.tranpol.2020.08.022
E. Kassens-Noor, M. Wilson, M. Cai, N. Durst, and T. Decaminada, "Autonomous vs. Self-Driving

Vehicles: The Power of Language to Shape Public Perceptions," Journal of Urban Technology (2020b) https://doi.org/10.1080/10630732.2020.1847983 Accessed January 1, 2021.

E. Kassens-Noor, M. Wilson, Z. Kotval-Karamchandani, M. Cai, and T. Decaminada, "Living with Autonomy: Public Perceptions of an AI-Mediated Future," Journal of Planning Education and Research (2021) https://doi.org/10.1177/0739456X20984529 Accessed January 25, 2021.

K. Korosec, "Tesla Plans to Launch a Robotaxi Network in 2020," Tech Crunch (April 22, 2019) https://techcrunch.com/2019/04/22/tesla-plans-to-launch-a-robotaxi-network-in-2020/

MAG, "2040 Regional Transportation Plan," (Phoenix, AZ: Maricopa Association of Governments, 2017) https://www.azmag.gov/Portals/0/Documents/2040-Regional-Transportation-Plan-FINAL_6-28-17.pdf?ver=2017-07-10-144803-100 Accessed September 25, 2018.

A. Martinho, N. Herber, M. Kroesen, and C. Chorus, "Ethical Issues in Focus by the Autonomous Vehicles Industry," Transport Reviews (2021) https://doi.org/10.1080/01441647.2020.1862355 Accessed February 4, 2021.

Metro, "2018 Regional Transportation Plan" (Portland, OR: Portland Metro, 2018) www.oregonmetro.gov/sites/default/files/2020/07/29/Adopted-2018-RTP-all-chapters.pdf Accessed November 24, 2019.

D. Milakis, B. van Arem, and B. van Wee, "Policy and Society Related Implications of Automated Driving: A Review of Literature and Directions for Future Research," Journal of Intelligent Transportation Systems 21: 4 (2017) 324–348. https://doi.org/10.1080/15472450.2017.1291351

A. Millard-Ball, "Pedestrians, Autonomous Vehicles, and Cities," Journal of Planning Education and Research 38: 1 (2018) 6–12. https://doi.org/10.1177/0739456X16675674

T. Miller and D. McAslan, "Self-Driving Ride-Share Service 'Waymo One' Has Launched: What's Next for Cities?" Meeting of the Minds (January 23, 2019) https://meetingoftheminds.org/self-driving-ride-share-service-waymo-one-has-launched-whats-next-for-cities-29661 Accessed January 23 2019.

MMPO, "Livability 2050" (Memphis Metropolitan Planning Organization: Memphis, TN, 2019) https://memphismpo.org/sites/default/files/public/documents/rtp-2050/Livability2050RTPAdopted09.12.19.pdf Accessed Oct 3 2018.

NCTCOG, Mobility 2045: The Metropolitan Transportation Plan for North Central Texas, (Dallas, TX: North Central Texas Council of Governments, 2018) https://www.nctcog.org/trans/plan/mtp/2045#plandocument Accessed September 24, 2018.

NJTPA, Plan 2045: Connecting North Jersey (Newark, NJ: New Jersey Transportation Planning Agency, 2017) https://apps.njtpa.org/plan2045/docs/11699_plan2045_v5_LowRes.pdf Accessed November 22, 2019.

NTSB, Collision Between Vehicle Controlled by Developmental Automated Driving System and Pedestrian (2019) https://www.ntsb.gov/news/events/Documents/2019-HWY18MH010-BMG-abstract.pdf Accessed November 22, 2019.

D. Orrell, "Are Transport Forecasting Models Accurate Enough?, World Finance (February 12, 2014) https://www.worldfinance.com/the-econoclast/are-transport-forecasting-models-accurate-enough Accessed February 22, 2020.

PAG, 2045 Regional Mobility and Accessibility Plan (Tucson, AZ: Pima Association of Governments, 2016). https://mk0pagrtahost21swg12.kinstacdn.com/wp-content/docs/pag/2020/08/2045RMAP.pdf Accessed December 17, 2018.

D. M. Pankratz, W. D. Eggers, K. Nuttall, and M. Turley, "Regulating the Future of Mobility: Balancing Innovation and the Public Good in Autonomous Vehicles, Shared Mobility, and

Beyond," Deloitte Review (January 2018) https://www2.deloitte.com/us/en/insights/focus/future-of-mobility/regulating-transportation-new-mobility-ecosystem. Accessed July 8, 2020.

S. Polzin, "Changing Travel Behavior: We Are Traveling Less, and More." Planetizen (August 20, 2018) www.planetizen.com/blogs/100166-changing-travel-behavior-we-are-traveling-less-and-more Accessed December 5 2018.

PSRC, "The Regional Transportation Plan—2018" (Seattle, WA: Puget Sound Regional Council, 2018) www.psrc.org/sites/default/files/rtp-may2018.pdf Accessed Sept 25, 2018.

R. Quay, "Anticipatory Governance: A Tool for Climate Change Adaptation," Journal of the American Planning Association 76: 4 (2010) 496–511. https://doi.org/10.1080/01944363.2010. 508428

RPCGB, "2045 Regional Transportation Plan" (Birmingham, AL: Regional Planning Commission of Greter Birmingham, 2019) www.rpcgb.org/regional-transportation-plan Accessed November 23, 2019.

RRTPO, "Plan 2040" (Richmond, VA: Richmond Regional Transportation Planning Organization, 2016). https://planrva.org/wp-content/uploads/2019/03/Plan2040-MTP-LRTP.pdf Accessed October 3, 2018.

RTCSNV, Access 2040: Enhancing Mobility for Southern Nevada Residents (Las Vegas, NV: Regional Transportation Commission of Southern Nevada, 2017) https://assets.rtcsnv.com/wp-content/uploads/sites/4/2019/06/20093531/Access2040_adopted.pdf Accessed Sept 25, 2018.

D. Sarewitz, "Anticipatory Governance of Emerging Technologies" in G. E. Marchant, B. R. Allenby, and J. R. Herkert, eds, The Growing Gap between Emerging Technologies and Legal-Ethical Oversight: The Pacing Problem (New York: Springer, 2011), 95–106.

M. A. Schreurs and S. W. Steuwer, "Autonomous Driving: Political, Legal, Social, and Sustainability Dimensions," in M. Maurer, J. C. Gerdes, B. Lenz, and H. Winner, eds., Autonomous Driving (Springer: Berlin Heidelberg, 2016), 149–171. https://doi.org/10.1007/978-3-662-48847-8_8

SEMCOG, "2045 Regional Transportation Plan for Southeast Michigan," (Detroit, MI: Southeast Michigan Council of Governments, 2019). https://semcog.org/rtp Accessed November 24, 2019.

SEWRPC, "Vision 2050," (Milwaukee, WI: Southeastern Wisconsin Regional Planning Commission, 2016) http://www.sewrpc.org/SEWRPCFiles/Publications/pr/pr-055-vol-1-complete-final.pdf Accessed October 3, 2018.

SPC, "Smart Moves for a Changing Region," (Pittsburgh, PA: Southwestern Pennsylvania Commission, 2019) https://www.spcregion.org/programs-services/transportation/smartmoves-long-range-plan-transportation-improvement-program/ Accessed November 24, 2019.

S. Stachura, "Why Pedestrian Deaths Are At A 30-Year High," NPR (March 28, 2019) www.npr.org/2019/03/28/706481382/why-pedestrian-deaths-are-at-a-30-year-high Accessed November 26, 2019.

B. Steckler, J. Coia, A. Howell, G. Kaplowitz, M. Stoll, and H. Yang, "Perfecting Policy with Pilots: New Mobility and AV Urban Delivery Pilot Project Assessment" (2020) https://cpb-us-e1.wpmucdn.com/blogs.uoregon.edu/dist/f/13615/files/2020/05/2020-Perfecting-Policy-with-Pilots-UNext-Online.pdf Accessed May 27, 2020.

J. Stilgoe, "Seeing Like a Tesla: How Can We Anticipate Self-Driving Worlds?" Glocalism: Journal of Culture, Politics and Innovation (2017) https://doi.org/10.12893/gjcpi.2017.3.2

J. Stilgoe, "Machine Learning, Social Learning and the Governance of Self-Driving Cars," Social Studies of Science 48: 1 (2018a) 25–56. https://doi.org/10.1177/0306312717741687
J. Stilgoe, "We Need New Rules for Self-Driving Cars," Issues in Science and Technology 34: 3 (2018b) 52–57.
J. Stilgoe, S. J. Lock, and J. Wilsdon, "Why Should We Promote Public Engagement With Science?" Public Understanding of Science 23: 1 (2014) 4–15. https://doi.org/10.1177/0963662513518154
J. Stilgoe, R. Owen, and P. Macnaghten, "Developing a Framework for Responsible Innovation," Research Policy 42: 9 (2013) 1568–1580. https://doi.org/10.1016/j.respol.2013.05.008
S. Szymkowski, "Waymo One Self-Driving Ride-Hailing Service Plans Public Expansion Next Year," CNET (December 5, 2019) www.cnet.com/roadshow/news/waymo-one-self-driving-rideshare-service-features-expansion/ Accessed January 20, 2020.
N. Thomopoulos and M. Givoni, "The Autonomous Car: A Blessing or a Curse for the Future of Low Carbon Mobility? An Exploration of Likely vs. Desirable Outcomes," European Journal of Futures Research 3: 1 (2015) 14. https://doi.org/10.1007/s40309-015-0071-z
USDOT, The Metropolitan Transportation Planning Process: Key Issues (2001).
N. E. Vellinga, "From the Testing to the Deployment of Self-Driving Cars: Legal Challenges to Policymakers on the Road Ahead," Computer Law and Security Review 33: 6 (2017) 847–863.
Z. Wadud and P. K. Chintakayala, "To Own or Not To Own—That is the Question: The Value of Owning a (Fully Automated) Vehicle," Transportation Research Part C: Emerging Technologies (2021) https://doi.org/10.1016/j.trc.2021.102978 Accessed February 17, 2021.
J. Walker, "How Good Are We At Prediction?" Human Transit (July 14, 2014) https://humantransit.org/2014/07/how-good-are-we-at-prediction.html Accessed February 19, 2019.
A. Wiek, D. Guston, S. van der Leeuw, C. Selin, and P. Shapira, "Nanotechnology in the City: Sustainability Challenges and Anticipatory Governance," Journal of Urban Technology 20: 2 (2013) 45–62.
R. Worthington, D. Cavalier, M. Farooque, G. Gano, H. Geddes, S. Sander, et al., "Technology Assessment and Public Participation: From TA to pTA" https://cspo.org/legacy/library/1301301001F12269256VO_lib_ECASTReportTAtop.pdf Accessed March 9, 2020.
W. Zhang, S. Guhathakurta, and E. B. Khalil, "The Impact of Private Autonomous Vehicles on Vehicle Ownership and Unoccupied VMT Generation," Transportation Research Part C: Emerging Technologies 90 (2018) 156–165.