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MEMORANDUM

To: **CMAP Transportation Committee**

From: CMAP staff

Date: June 5, 2017

Re: Alternative Futures: What if technology enabled innovative transportation?

As part of ON TO 2050 development, CMAP is undertaking an "alternative futures" planning process focusing on exogenous factors that are largely beyond the control of any one entity, including CMAP and our regional partners. These factors include the environment, consumer preferences, technological advancements, and macroeconomic trends.

Based on research and feedback from stakeholders, CMAP envisions five different futures for the region, imagining life in 2050 where…

- Climate change impacts have intensified.
- More people have chosen walkable communities.
- The economy has transformed.
- Innovations have enhanced transportation.
- Public resources are further constrained.

The Alternative Futures planning exercise, which draws upon ongoing CMAP work and ON TO 2050 products, will inform the agency's phase of broad public engagement in spring and summer 2017. CMAP will identify the key macro-level drivers shaping each future and their potential impacts. With written and interactive materials, staff will depict the imagined futures' effects on residents and businesses. With the assistance of CMAP working committees, CMAP will also propose strategies to help mitigate potential negative outcomes and capitalize on opportunities that might arise. At the end of the futures engagement, staff will emphasize crosscutting strategic actions and policies that will help the region thrive across a wide range of possible outcomes.

This memo, the third in a series, imagines a future in which innovative transportation technologies improve the mobility of people and goods. For the purposes of this exercise, CMAP assumes that sensors, communications technology, and vehicle automation systems continue to improve in performance and see dramatic reductions in cost. CMAP further assumes that fully automated cars, trucks, and transit vehicles that can operate without human intervention in all conditions are available for fleet and individual purchase, and that by 2050 the majority of vehicles on the road are partially or fully automated. These forecasts of technology adoption assume that the federal and state government has developed policies, regulations, and certification processes to ensure the safe operation of automated vehicles on roads with a mixture of automated and non-automated vehicles.

In 2050, innovative transportation technologies make travel convenient and improve the mobility of people and goods. Travelers, communities, and businesses have access to more accurate, real-time information to make smarter decisions. Faster and more convenient car travel leads to more auto oriented development on the region's edge. Automated cars, transit, and delivery vehicles change land use patterns in communities throughout the region. Automated vehicles provide increased safety and convenience for many residents but may not be accessible or affordable to everyone. High-tech freight shipping that incorporates multiple modes of transportation (e.g., rail, shipping, and/or trucking) grows in prominence, resulting in changing freight traffic and industrial space needs.

Primary driver: technological innovations in transportation improve mobility of people and goods

In 2050, innovations in transportation technology -- including smart infrastructure and automated and electrified personal cars, trucks, and transit vehicles -- make travel and goods movement faster and more convenient.

In this future, connected vehicle technologies would enable parts of the transportation system, like streets, traffic signals, road signs, and vehicles to send and receive information to each other to provide greater safety, comfort, entertainment, and convenience. Automakers, transportation agencies, and transit authorities would routinely equip their vehicles and other infrastructure with smart communications technology, which would help vehicles send and receive real-time information about road conditions and avoid delays caused by congestion or nearby crashes. Transportation agencies would be able to quickly re-route cars and trucks, respond to accidents, and even dynamically adjust traffic signal timing, speed limits, and tolls to reduce congestion and improve the speed and reliability of transportation.

In addition, all vehicles would have some level of automation in 2050. Some lower-level automated technologies, including adaptive cruise control and parking assist, are already widely available in model year 2017,[1] and the first test fleets of more highly automated vehicles are operating in some cities (see figure below for examples of technologies along the vehicle automation spectrum).[2] Production versions of these technologies that allow drivers to take their hands off the wheel and feet off the pedals could become more common by 2030. Due to labor shortages and tight margins in the shipping industry, the first types of vehicles to be fully automated would be large trucks traveling long-distance routes.[3] The combination of autonomous and connected vehicle technologies would enable the use of truck platoons -- i.e., a line of closely spaced trucks traveling together on a highway, with only the lead truck in the platoon requiring a driver.[4] Automated safety technologies like collision mitigation systems for trucks and automatic train control for rail would improve freight safety.[5] Freight companies and automakers could eventually develop smaller automated delivery vehicles that can safely navigate more complex, urban areas. Automated shuttles could also provide last mile connections between fixed route transit and people's final destinations, particularly in lower-density areas where frequent fixed-route public transit is not economically viable.

As 2050 approaches, technological advances and economies of scale in remote sensing technology could make fully automated cars affordable and widely available for individual purchase. Fully automated cars may not even have steering wheels, gas pedals, or other controls, as the car would handle all driving conditions without the occupant's help. If they are no longer a luxury item, automated cars could be used by many middle class households. While

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[1] Consumer Reports. "Cars with Advanced Safety Systems." March 8, 2017. http://www.consumerreports.org/car-safety/cars-with-advanced-safety-systems/

[2] Chafkin, Max. "Uber's First Self-Driving Fleet Arrives in Pittsburgh This Month." Bloomberg Businessweek, August 18, 2016. https://www.bloomberg.com/news/features/2016-08-18/uber-s-first-self-driving-fleet-arrives-in-pittsburgh-this-month-is06r7on

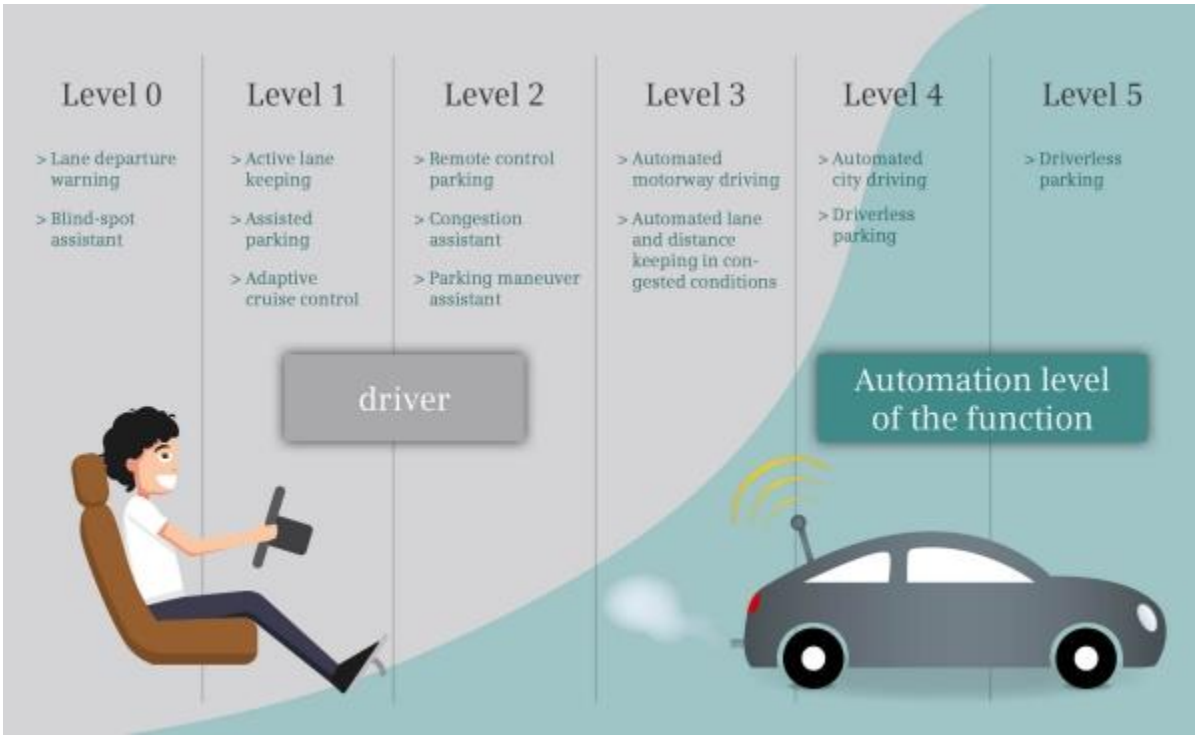
[3] O'Brien, Chris. "One-Third of all Long Haul Trucks to be Semi-Autonomous by 2025." *Trucks.com*, September 12, 2016. https://www.trucks.com/2016/09/12/one-third-trucks-autonomous-2025/.

[4] European Truck Platooning Challenge, "What is Truck Platooning?", https://www.eutruckplatooning.com/About/default.aspx

Kahaner, Larry. "Platooning is closer than you think – just like the trucks" *FleetOwner*, May 29, 2015. http://fleetowner.com/driver-management-resource-center/platooning-closer-you-think-just-trucks

[5] Association of American Railroads, 2016 State of the Industry Reports, "Report 1: Safety and Innovation." https://www.aar.org/report/Documents/AAR%20State%20of%20the%20Industry%202016%20Full%20Report.pdf.

some companies may provide taxi-like services where residents can hail rides in an automated vehicle, these services may only be economically viable in the densest parts of the region where car ownership rates are low and parking space is at a particular premium.



Source: Siemens, 2016

Innovations in fuel efficiency and alternative fuel technology could develop in parallel with advances in vehicle automation and reduce both air pollution and cost to drivers. Due to increasingly stringent fuel economy standards, vehicles that use conventional gasoline will become more efficient, and more than a quarter of cars and light duty trucks could be powered by electricity and other alternative fuels.[6] Passenger cars are most likely to be electrified, with a dramatic increase in plug-in and hybrid electric vehicle market share projected by 2050. For heavy duty trucks, the increased aerodynamics associated with platooning would reduce fuel consumption. New locomotives would require less fuel, reducing operating costs and improving air quality, a process that is already underway because of federal air quality

[6] US Energy Information Administration, Annual Energy Outlook 2017. http://cmap.is/2snwnMk

standards[7]. Cleaner and quieter equipment would be widely implemented in rail yards, reducing impacts on neighboring communities. Advanced technologies would also enable more efficient operations within freight terminals. [8, 9]

Technology would also change the nature of retail and delivery. More and more consumers would place orders online, and greater demand for home deliveries would increase the number of trucks on the road even if drones become a viable last-mile delivery method for some especially time-sensitive items. New information technologies and automation would help optimize operations within warehouse and distribution centers, as well as the scheduling, routing, and tracking of deliveries.[10]

Life in 2050 with innovative transportation technologies

Region's residents benefit from improved road safety and increased independence

In the Chicago region in 2014, 366 people were killed and 41,858[11] injured in motor vehicle crashes, and motor vehicles were the thirteenth most common cause of death nationwide. Driver actions were the critical reason for 94 percent of U.S. crashes.[12] By 2050, new

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[7] US Environmental Protection Agency, Emission Standards Reference Guide, EPA Emission Standards for Nonroad Engines and Vehicles. "Locomotives: Exhaust Emissions Standards." https://nepis.epa.gov/Exe/ZyPDF.cgi?Dockey=P100OA09.pdf.

[8] Natural Resources Defense Council, "Clean Cargo: A Guide to Reducing Diesel Air Pollution from the Freight Industry in Your Community." https://www.nrdc.org/sites/default/files/clean-cargo-toolkit.pdf

[9] Center for Neighborhood Technology, 2015. Freight Train to Community Prosperity: Metrics for the Integration of Community Economic Development and Efficient Freight Movement." http://www.cnt.org/sites/default/files/publications/CNT_FreightTraintoCommunityProsperity.pdf

[10] Whelan, Robbie. "Fully Autonomous Robots: The Warehouse Workers of the Near Future." *Wall Street Journal*, September 20, 2016. https://www.wsj.com/articles/fully-autonomous-robots-the-warehouse-workers-of-the-near-future-1474383024

Kitroeff, Natalie. "Warehouses promises lots of jobs, but robot workforce slows hiring." *Los Angeles Times*, December 4, 2016. http://www.latimes.com/projects/la-fi-warehouse-robots/

[11] Illinois Department of Transportation Division of Traffic Safety, " 2014 Illinois Crash Facts and Statistics." http://www.idot.illinois.gov/Assets/uploads/files/Transportation-System/Resources/Safety/Crash-Reports/crash-facts/2014%20CF.pdf

[12]US Department of Transportation, Traffic Safety Facts, "Critical reasons for crashes investigated in the national motor vehicle crash causation survey," February 2015. https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115

transportation technology could dramatically reduce crashes caused by human error, resulting in a significant decline in crashes and injuries. Cyclists and pedestrians could particularly benefit from automated vehicle technologies that sense the presence of and yield to non-motorized traffic. Instead of building infrastructure to withstand impacts caused by human error, (e.g., wider lanes, medians, guard rails, protected bike lanes, etc.), transportation agencies could reduce construction costs by scaling back this infrastructure. Some of these changes in road design could allow roads to handle more vehicles without expanding the roadway.

Automated vehicles could also allow populations that currently cannot operate a vehicle to travel more easily. Elderly and disabled residents who can afford automated vehicles would be able to travel with less assistance, improving their quality of life. People with disabilities would find it easier to reach employment, adding to the economy. More seniors would be able to reach medical appointments and shop for groceries, extending their ability to live independently.

More convenient long-distance driving changes travel behavior

As vehicles control more responsibility for navigation, people who once focused on the road would become passengers, able to spend time on other pursuits. Each person could customize their vehicle to allow them to work, read, or even sleep as they commute each day. Investments in sensors and other highway infrastructure could speed automotive commutes for less automated vehicles as well. Long commutes may become common, as people are able to remain productive en route. Bicycling and pedestrian travel could decline if even short-distant auto travel becomes more convenient. Increases in vehicle travel could partially counteract some of the potential benefits of automated vehicle technologies. For example, vehicles could drop off passengers at their destination before traveling to distant parking facilities, running errands, or returning home for use by another household member. Vehicle owners could even send their cars on aimless trips if zero-passenger driving is less expensive than parking. If many vehicles operate without passengers, congestion could become very acute even with smart technology, particularly in dense commercial areas. Communities would need to redesign streets to manage this congestion.

Public transit, which has long provided productivity advantages to passengers, may struggle to compete for customers, particularly if people are attracted to private services that can offer more attractive amenities and comforts. But fast, frequent transit with dedicated right of way could allow riders to bypass congestion and would continue to be competitive with autonomous vehicles, especially for the highest density parts of the region. Bus service on congested streets may face increased competition for road space as more people use personal automated vehicles for commuting. Low frequency routes through less dense neighborhoods would likely experience particularly steep declines in ridership as new autonomous options become available. Some of these autonomous options may include on demand shuttle or van

services provided by public and private operators to connect to higher frequency and capacity routes.

More frequent delivery of goods increases freight traffic

Changes in freight technologies, as well as the increased consumer preference for on-demand and retail models, would increase the volume of goods moved across all modes. Truck platooning and improved routing may reduce labor costs and allow trucks to operate beyond the current hours-of-service regulations. Given its extensive transportation network, multimodal connections, and specialized freight and logistics workforce, northeastern Illinois is well positioned to remain North America's preeminent freight hub in 2050. New investments will be needed to help the region's infrastructure keep up with changing technologies and increased volumes of freight activity.

Advanced transportation technologies also present new opportunities to reduce the negative community impacts of freight movements. As freight vehicles become cleaner and quieter, operators may be able to schedule more overnight and early morning deliveries to take advantage of faster travel times in off-peak periods without increasing noise levels in residential communities. Further, smaller and new types of freight vehicles could be used to make deliveries in dense urban areas, reducing congestion and safety concerns on local roads.

Auto-oriented development patterns expand on the region's fringe

Easier, more convenient travel by all modes could fuel another round of suburban expansion, similar to what occurred after the construction of the Interstate highway system. People and employers could move to less dense parts of the region to take advantage of lower land prices and more open space while still having convenient access to all their daily needs. With less demand, some existing denser communities may see declines in population and residential property values. Substantial development on agricultural land and in natural areas could occur, requiring new infrastructure, including roads, utilities, and drinking water, sewer, and stormwater systems. Some communities could face fiscal challenges in paying to maintain or rebuild the additional infrastructure. New development that relies on groundwater could accelerate aquifer depletion in some parts of the region; communities who are dependent upon already stressed groundwater supplies could face growing water supply issues.

Land use patterns change within communities

Innovations in freight delivery and easier passenger travel would allow businesses to access a larger market for customers and employees within a reasonable travel time. Larger market sizes could increase competition and specialization. Smaller local businesses may not be able to compete. The combination of increased competition and the replacement of brick-and-mortar retail with online shopping may mean that some communities are not able to sustain local commercial corridors. Large format retail land uses like shopping malls and big box stores

would have substantial vacancy rates. Communities with fewer sales-tax-generating businesses have fewer options to raise municipal revenues, and the decline of large-format retail by 2050 could reduce sales-tax revenues for some local governments. If online shopping and on-demand delivery continue to grow, parking needs in commercial and business districts would decline, while needs for loading zones and delivery areas would increase. Parking facilities could also be located more strategically if automated vehicles can drop off their passengers and park themselves farther from dense activity centers. Land currently used for parking would be available for redevelopment.

Infrastructure maintenance and modernization needs increase while revenue declines

The widespread implementation of advanced transportation technologies would change infrastructure investment needs. These technologies hold promise to greatly improve the efficiency of the transportation network -- moving both people and goods more quickly, safely, and cheaply -- and reduce maintenance costs over time. Asset management could be much more cost effective with new technology, as it would become easier to monitor the condition of infrastructure and vehicles and optimize their repair and replacement. Automation could reduce the labor cost of transit, which is currently the largest contributor to operating cost.

However, advanced transportation technologies require significant upfront capital costs. For example, sensors and cameras would need to be installed in pavements, traffic signals, and transit vehicles; communication systems would need to be in place to connect these sensors to each other and a central database; and new systems would need to be installed to monitor and analyze the vast new amounts of data available. These new systems would need to be maintained and operated over time, requiring not only new forms of capital expenditures for transportation agencies but also new staffing requirements.

While it would be standard practice in the future to build new infrastructure compatible with advanced technologies, the region's vast existing transportation network would need to be retrofitted to unlock the full benefits of new transportation technologies. These efforts could first be prioritized to the region's largest and mostly heavily used transportation systems, such as the expressway system and major transit rail lines. Implementation on local roads and other lesser-used facilities may be a lesser priority. Not all local communities would be well placed to invest in advanced transportation technologies, which is described in more detail in the following section.

At the same time as new capital expenditures are required of transportation agencies and local communities, available resources would likely decline. Today, transportation revenues for state and many local agencies rely heavily on gas taxes and vehicle registration fees. If this revenue

structure does not change, revenues will decline by 2050 as cars and trucks become even more fuel-efficient, and more vehicles run on electricity or alternative fuels.

Value of data and data analysis increases

The data being constantly sent and received by transportation infrastructure, vehicles, and individuals have the potential to provide great value to transportation agencies, private companies, and the public. However, transforming this flood of data into information that can help inform decision making will require substantial investments in data storage and analytical capabilities, including staff with expertise in analyzing large datasets. The public sector has long collected a vast amount of data and makes much of it freely available to the public. The private sector is also collecting large amounts of data that are increasingly relevant to planning efforts but access to this data may be restricted by proprietary and privacy concerns.

Air quality improves, but power grid becomes strained

Despite increased automotive travel, improved fuel efficiency and increased market share for electric vehicles would reduce greenhouse gas emissions and improve air quality throughout the region. Improvements in freight technology in particular would benefit areas near intermodal facilities. As a result, populations near these facilities, especially those that are susceptible to air pollution, including children, the elderly, people of color, and low income residents, would have fewer respiratory problems. Some technologies may require entirely new infrastructure systems, such as a network of battery charging stations for electric vehicles. Utility companies and communities would need to make investments in upgrading these other systems to support advanced transportation technologies. However, the transportation sector's increased reliance on electricity could strain the region's grid and lead to more power outages, which in turn would negatively affect quality of life and the economy.

Disproportionately affected communities

In a future with innovative transportation technology, access to jobs, education, and other services would continue to be difficult for people without cars or income to afford new mobility services. Private mobility operators could focus service in the most profitable neighborhoods and provide less benefit to lower income neighborhoods. Private services may also not be viable in low density areas of the region, leaving residents with few alternatives to car ownership. Declining transit ridership and competition from private mobility providers may result in cuts to transit service, resulting in fewer options for low-income residents, many of whom already have long commutes to employment centers and have less access to technology and technological literacy. Access to routes with the most advanced technology may require users to pay tolls and may require vehicles to have the latest communication technology. People who choose not to buy or cannot afford automated vehicles may have to take more indirect or more congested routes on roads equipped with less technology. Although seniors in particular stand to benefit from automated vehicles and private transportation services, lack of technological

literacy and general wariness may discourage seniors from embracing these new mobility options. Increased auto-oriented development patterns and decreased local retail could make it more difficult for people to reach destinations on foot or by bicycle.

While costs would decline over time, investment in the technology and analytics to improve public infrastructure would still not be cheap or affordable to every community or agency. Prosperous communities would have the capacity to upgrade traffic lights, construct command centers, improve transit amenities, and adjust to new standards. However, other communities would be overwhelmed with the cost and scale of the legacy infrastructure that needs to be upgraded. These communities may suffer increased congestion from automated vehicles and increased freight traffic, and bicyclists and pedestrians in these communities may be particularly vulnerable. Businesses and residents would avoid communities that cannot keep up with the latest infrastructure, continuing a cycle of disinvestment.

Strategies to prepare for innovative transportation technologies

The pace of technological change is difficult to predict, and by 2050 we are likely to see technological innovation that we cannot imagine today. However, many actions can be taken today to better prepare the region for future technology. Below are broad strategies to undertake now to prepare for this future. These strategies are described in more detail in related CMAP strategy papers and research (see Attachment A). Each broad strategy also includes questions for stakeholders that will help CMAP better understand preferences or message the issues or solutions. These questions may be included in future engagement with stakeholders.

1. Set the stage today for new transportation technologies

The region should build on existing projects and planning processes to put in place the building blocks for future innovation. While it is difficult, if not impossible, to predict the exact technologies that will be in use in 2050, it is important to identify the core supporting investments that can enable a wide range of technologies, as well as determine the best and most equitable strategies to pay for these investments and the most strategic time to adopt them. For example, most innovative transportation technologies, from real-time traffic information to automated vehicles, will rely on a robust communications network. Preserving right of way for transportation and communication infrastructure would lower the cost of future projects. For example, as part of the reconstruction of I-90, the Tollway is building power and fiber optic infrastructure into the road that can be used in the future without additional digging. In some other cases, it may be prudent to delay investments until technology is tested with proven benefits that justify the costs and is also more mature, standardized, and affordable. For example, when procuring new vehicles, agencies could set aside space for

communications technology, but wait to purchase the technology until near the end of the procurement process when technology has further developed. In the longer term, transit agencies should monitor the advances in on-demand routing technology and automated shuttle vehicles being developed and piloted by the private sector.

Adoption and promotion of industry standards for communication and technology increases the likelihood that upgrades would be possible without complete replacement of existing infrastructure, which would yield cost savings for transportation agencies and municipalities. CMAP and partners should encourage the development of such standards, and while they are being developed should attempt to make investments that do not depend on a single, proprietary technology. Municipalities and agencies should begin discussion about technology investments by identifying the problem to be solved or desired outcome of the investment.

2. *Prioritize technology investments that offer cost savings, reduce congestion, and improve safety*

Technology has the potential to dramatically reduce operating costs for the region's transportation agencies. Given that current and projected levels of funding are insufficient to maintain the region's existing infrastructure in its current condition, CMAP and partners should take advantage of the opportunities presented by technology to reduce operations, labor, and maintenance costs. For example, transit agencies may be able to employ dynamic routing technologies on low ridership routes and paratransit service to decrease operating costs. Investments in Lidar (Light Detection and Ranging) remote sensing technology can help highway agencies conduct more rapid and efficient monitoring and repair of roads and bridges. The region can learn from other cities and regions as well as from the private sector. In addition, many completely new cost and time saving innovations may emerge in the coming decades. CMAP and other agencies should continue to monitor technological advances to evaluate their potential, support pilot projects of promising innovations, and develop best practices for the region as a whole.

In this future, the proliferation of zero-occupancy vehicles and the increase of just-in-time, on-demand deliveries could lead to increases in congestion. Innovative transportation technologies would allow the region to make more efficient use of existing infrastructure, not only reducing costs for public agencies but also reducing congestion. Congestion reduction strategies would be particularly important to minimize increases in vehicle miles traveled caused by zero-occupancy vehicles, and the region should develop policies that incentivize higher occupancy and/or discourage travel of zero-occupancy vehicles. Congestion pricing via the application of variable toll rates along major expressways would allow prices to rise during the morning and evening peak periods and encourage drivers during peak periods to switch to higher occupancy modes, routes, or times of day. If automated vehicles become prominent, tolls for zero

occupancy vehicles should be higher than for occupied vehicles, particularly during peak periods and on congested routes. This strategy reduces congestion and limits the need for costly highway expansion. New revenues could pay for maintenance costs, and be invested in additional transit services or local road improvements in priced corridors.

Sixty percent of congestion is caused by weather, construction, accidents, and other one-time incidents. Automated vehicles can help reduce accidents, but transportation agencies should also leverage advanced information technologies to improve safety and reduce congestion through better use of existing assets. For example, intelligent transportation systems could better connect travelers with multimodal options in real time, provide advance warnings of dangerous conditions ahead, optimize the timing of traffic signals or transit vehicles, and re-route vehicles around incidents and congestion.

3. Increase commitment to public transportation and modernize transit systems

Even in a future with privately owned automated vehicles and new private transportation services, mass transit would remain the most efficient and cost-effective way to move large numbers of people to the region's population and economic centers. Without mass transit, dense population and job centers would be overwhelmed by congestion. Investing in maintenance and modernization of the public transit system, particularly those improvements that will help the system capitalize on transportation innovations, and encouraging transit-supportive infill development can contribute to the region's economic vitality, promote inclusive growth, and reduce pressure on the region's roadway network.

Communities should preserve space on roads for transit and use technologies like transit signal priority to ensure that the region's infrastructure can be used to move large numbers of people efficiently. As other modes of transportation become more technologically advanced, transit agencies will need to make investments to remain relevant and attractive to riders. While transit will likely always be competitive on price, improving the speed, frequency, and reliability of routes can make transit an even more attractive choice. Transit agencies should build on and expand the technology they have to provide more accurate, real-time, and comprehensive information that can be easily accessed by customers. Agencies should continue monitoring travel behavior and customer satisfaction to determine whether investments in amenities can attract additional ridership. Agencies should also consider partnerships or pilots of new models of operating that could solve the last mile problem in lower density areas. Pilot projects should be designed to provide measurable outcomes that help agencies better understand the conditions under which these technologies are most effective. In addition, CMAP and agencies should continue to provide technical assistance and other tools (e.g., zoning updates) to affect land use patterns so more areas can retain or achieve population and job densities that can

support financially feasible transit systems and investments.

4. Ensure innovative technologies are accessible to all communities

Access to the latest technology and the benefits it can bring will not be cheap. Low income individuals may find it difficult to access the latest technology. If new premium mobility options cause declining transit ridership, transit agencies may struggle to provide services that provide crucial access to jobs and other destinations for those who cannot afford car ownership. CMAP and partners should analyze the impacts of emerging mobility options on low income and underserved populations and explore ways to ensure affordable mobility in these communities. Maintaining and improving existing public transit is essential to maintaining affordable mobility for all individuals. Before investing in technologies that modernize the public transit system, agencies should ensure these services still provide access to people with limited access to technology. A bus that can be hailed using a smartphone is of little benefit for those who do not own a smartphone.

Autonomous vehicles could also overwhelm some existing roads and require special improvements, leading to exclusion of other modes either by design or circumstance. Large numbers of vehicles moving close together would make biking and walking uncomfortable. By maintaining and expanding space for bikes and pedestrians (see strategy 6 above), streets can remain accessible to everyone.

5. Create mutually beneficial partnerships by sharing transportation data

If more of our infrastructure becomes capable of generating and receiving data, cooperation between different parties would become more important. Governments would need to develop new standards and tools for sharing information. Autonomous vehicles would need information not only about roads but about the other vehicles on the road and driving conditions (e.g., weather, accidents). The technology requirements may exceed the resources of some smaller communities. Partnerships between various levels of government and the private sector would be critical to developing and maintaining an efficient transportation network. Municipalities and transportation agencies should ensure that partnerships advance regional goals related to equitable mobility, congestion mitigation, and increased operating efficiency and cost savings.

Government data is a valuable resource that should be shared between public agencies and with the general public whenever possible, while protecting individual privacy and ensuring public safety. Similar expectations for data sharing and transparency should be established for private companies that provide mobility services in partnership with the public sector. CMAP and partners should be sure to incorporate data sharing agreements into partnerships with the

private sector, particularly in exchange for access to dedicated right of way (e.g., curbside pickup areas, transit lanes) or other public resources (e.g., fare subsidies).

6. Conserve critical natural and agricultural areas

While autonomous vehicles and increased communications technology may make commutes easier, they may also expand the region's footprint and infrastructure costs. Willingness to commute long distances may increase the demand for greenfield development, increasing pressure on groundwater, and food production, and making open space and natural resource preservation more difficult. Agricultural and natural areas are vital assets in our region, and their value should be weighed carefully when communities consider development opportunities in these areas. Communities should strengthen natural land protection and stewardship of natural and agricultural areas experiencing increased development pressure as a result of changing travel patterns, prioritizing areas that provide hard-to-replace ecosystem services[13], help preserve habitat connectivity, or are critical to our agricultural economy. CMAP can aid communities by helping to identify such high quality lands and should work with local partners to plan for land protection and secure a dedicated source of funding for preservation efforts.

New greenfield development should be located and designed in such a way to reduce impacts, maintain ecosystem functions or preserve agricultural uses, reduce transportation infrastructure costs, build municipal financial health, and address other community goals. For example, conservation-oriented development allows for compact design that can minimize the cost of new infrastructure, mitigate impacts to the environment, and protect natural resources on site. CMAP should work with municipalities to promote best practices in conservation design and minimize development impacts on natural lands. Municipalities should incorporate long-term infrastructure construction and maintenance costs into decisions about development expansion.

7. Identify opportunities for flexible design and adaptive reuse as part of local planning

Given the potential for transportation technology to substantially alter demand for retail and parking spaces, municipalities should encourage new development that can be used for multiple purposes or repurposed as space needs change. For example, they could consider the impact of declining need for parking when conducting downtown plans or local visioning exercises, potentially identifying existing parking lots that would be a priority for

[13]The Ecological Society of America defines ecosystem services as "the processes by which the environment produces resources… such as clean water, timber, habitat for fisheries, and pollination of native and agricultural plants." http://www.esa.org/ecoservices/comm/body.comm.fact.ecos.html

redevelopment. Municipalities should consider changing zoning ordinances and eliminating minimum parking requirements, particularly in higher density areas where transit and non-motorized transportation options exist, and allow market demand to drive parking space provisions. Flexible building design has become an increasing focus of architects and developers, and CMAP and municipalities should explore ways to ensure that new parking garages can be converted into office, retail, or residential space if demand for parking declines.[14] Without people at the wheel, cars can park themselves in smaller spaces, and existing garages could potentially accommodate more vehicles.

Municipalities may also need to redesign streets to accommodate more frequent deliveries, provide dedicated space for transit, and provide a comfortable environment for bikes and pedestrians. Some existing on-street parking may need to be converted into on-street loading zones for deliveries and passengers. Despite the potential safety benefits of automated and connected vehicles, increased auto traffic moving at higher speeds could make streets more intimidating for bikes and pedestrians and create barriers to access. Communities should adopt complete streets policies that provide a comfortable environment with ample right of way for pedestrians and bicyclists.

8. Encourage infill development and placemaking in existing communities

If transportation technology facilitates easy travel, residents will increasingly make decisions on where to live based on other factors, including a community's quality of life. Investing in existing communities can increase their attractiveness to potential residents and could reduce the need for costly new infrastructure and mitigate development pressures in agricultural areas and open space. Some of this new investment could consist of placemaking efforts to enhance community character and aesthetics. Placemaking is the process of creating unique spaces that capitalize on a community's assets to promote vibrancy, investment, and quality of life. Placemaking strategies highlight the unique elements of a place, such as its architecture, history, or other aspects of its character, through events, preservation efforts, streetscaping, public art, and other activities and projects.

9. Reform tax policy to support a range of land uses

Changing technology will change the way that residents and businesses buy and receive goods. More goods will be customizable, purchased online, and delivered in short timeframes. This has

[14] The city of Denver requires the ground floor of stand-alone parking garages to be suitable for conversion to active non-parking use. http://www.denverpost.com/2016/10/15/denver-developers-future-parking-self-driving-cars/

the potential to change the region's land use mix and transportation needs. In particular, the changing nature of the retail industry would have significant impacts on local governments' ability to raise revenues and provide public services. By 2050, communities that depend on revenues from large-format retail stores may struggle to replace declining local sales taxes under the current tax structure. At the same time, increased online ordering of goods and shortened supply chains would increase truck traffic on local roads, raising costs for local governments to maintain them. Increased industrial, freight, and intermodal facilities to handle increased shipping of consumer goods may particularly affect some local routes, while providing insufficient local revenues.

To prepare for these significant shifts, CMAP and other partners should explore strategies to ensure that all municipalities would have the ability to generate revenue to support land uses that are important to their community's economic, quality of life, and other goals, even during significant market shifts. For example, expanding the sales tax base to include additional services would help to provide additional revenue for communities. Cook County should also phase out property tax assessment classification to help reduce commercial and industrial property tax rates in many areas of the county. High tax rates can prompt a cycle where new businesses do not locate in the community, resulting in a tax base that grows more slowly than the cost of public services, which can lead to even higher tax rates for businesses and residents alike. This challenge could make it more difficult to redevelop grayfield sites in some communities.

Next steps

Following committee review and feedback, this memo will be finalized and used to inform the development of MetroQuest, an online platform that will allow residents to learn about and select strategies to prepare for a future where technology enables innovative transportation. In addition, CMAP has developed an interactive kiosk illustrating the key features of this future. The kiosks are featured on a digital display hosted at various locations throughout the region and made available online. The MetroQuest site and kiosks will be used during an intensive public engagement period, which kicked off in April 2017.

Four other potential futures for the region have also been selected for exploration. These futures will be oriented around what the region would be like if climate change impacts intensify; if the regional economy is transformed; if more people prefer to live in walkable communities; and if federal and state public resources are further constrained. These futures will also be accompanied by interactive kiosks and MetroQuest platforms. Staff will also develop a final memo where the recommendations in ON TO 2050 strategy papers will be analyzed through the lenses of the five alternative futures. The strategies that apply across many of these futures will help to inform which strategies to prioritize in ON TO 2050, which will be completed in October 2018.

Attachment 1: Related CMAP products by strategy

Strategy	Related CMAP ON TO 2050 strategy papers
1. Set the stage today for new transportation technologies	Highway Operations, Transit Modernization, Transportation Technology
2. Prioritize investments that offer cost savings and reduce congestion	Transportation Funding Mechanisms, Asset Management, Highway Operations, Transportation Technology, Traffic Safety
3. Increase commitment to public transportation	Transit Modernization, Reinvestment and Infill
4. Ensure innovative technologies are accessible to all communities	Inclusive growth, transportation technology
5. Create mutually-beneficial partnerships with private transportation providers	Transit modernization, Transportation technology
6. Conserve areas that provide critical agricultural and ecosystem services	Lands in Transition, Integrating Green Infrastructure
7. Identify opportunities for flexible design and adaptive reuse as part of local planning	Transportation Technology, Reinvestment and Infill
8. Promote walkable, mixed-use developments in urban areas	Reinvestment and Infill, Placemaking
9. Reform tax policy to support a range of land uses	Tax Policies and Land Use Trends