CONNECT Beyond

A Regional Mobility Initiative

Emerging Mobility Trends

May 2021

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Introduction

Our region is growing and developing at an immense rate. This growth raises important questions about the future of mobility, accessibility, and connectivity for the 12 counties in and around the Charlotte metropolitan area.

Transportation is critical for keeping a region moving. Transportation and transportation options help enhance the quality of life for area residents and visitors by providing greater access to education, healthcare, and recreational activities. These options impact economic development and the availability of goods and services by bringing more jobs within reach of the greater region. Areas that are seamlessly interconnected by a variety of transportation methods are far more likely to attract people, business, investment, and new opportunities.

To help address the issues of seamless transportation connections, the region embarked on a project called CONNECT Beyond. CONNECT Beyond is a two-state, 12-county regional mobility initiative coordinated by the Centralina Regional Council and the Metropolitan Transportation Commission to create a unified regional transit vision and plan (Figure 1).

CONNECT Beyond Study Goals

- Define a single, coordinated transit vision for the project study area that includes multiple transportation modes.
- Identify high-capacity transit corridors that build upon and complement the Charlotte Area Transit System (CATS) 2030 System Plan and other regional and local transportation plans.
- Strategize on key topics and methods for regional coordination that cross modes of transit as well as organizational and geographic boundaries.
- Develop action-oriented implementation approaches that support:
    - Improved mobility and access.
    - Effective, regionally coordinated transit investments.
    - Coordinated and resilient transit operations to meet the needs of a growing and changing region.
    - Environmentally sustainable investments and policies.
    - Advancement of equitable and community-driven improvements.

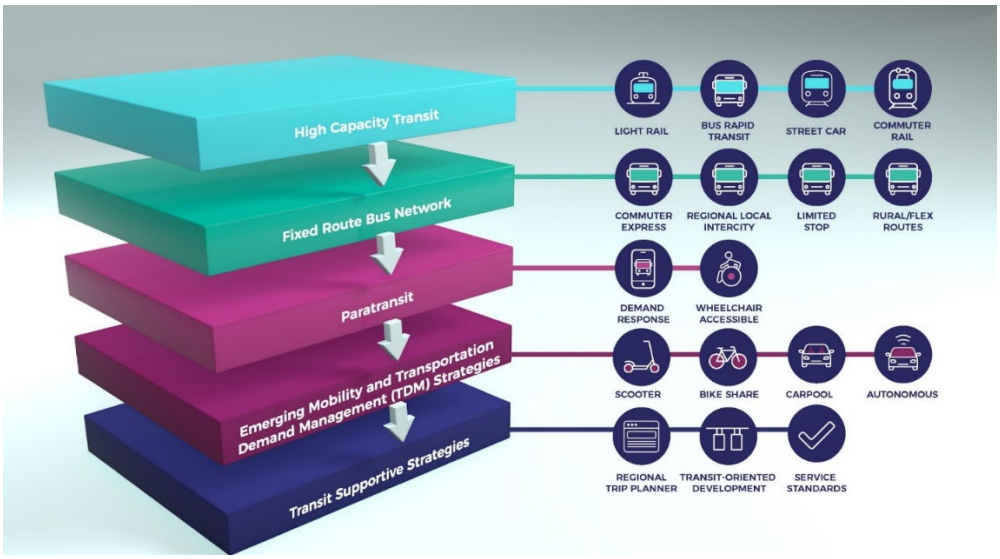
FIGURE 1. CONNECT BEYOND STUDY GOALS

CONNECT Beyond is planning for the region's transit future in four distinct steps:

1. Evaluating the transit system
2. Identifying high capacity transit corridors
3. Complementing the network with other mobility options as well as options to connect outer areas of the study area.
4. Developing implementation strategies that support area municipalities, transit agencies, and planning organizations

CONNECT Beyond's total mobility network (Figure 2) will offer:

- High capacity transit, including LRT, BRT, and Commuter Rail, and several other modes
- Fixed route bus, including local regional bus service, flex routes, neighborhood circulators, and other service delivery options
- Support services, including paratransit service and demand response
- TDM strategies such as vanpool, carpool, and walking/biking to work, as well as mobility hubs and new and emerging technologies
- Transit supportive strategies, such as transit oriented development a regional trip planner, or other investment opportunities



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Purpose

The purpose of this memo is to document major shifts and emerging mobility trends that are relevant to the goals of CONNECT Beyond. The memo also assesses and recommends regional mobility actions related to emerging trends and technologies in transportation/transit across the US. Understanding the relationship of transportation technology trends to the region's varying contexts – urban, suburban, rural; small towns and major central city – will support future-ready near-term, low-cost as well as longer-term more expensive investments that leverage new technology and services while mitigating risk and uncertainty.

The first section of this memo offers a broad summary of shifts in the transportation sector as evidenced before and during the COVID-19 pandemic. Based on an understanding of the region's priorities for future investment, the consultant team has recommended regional mobility strategies related to emerging trends and technologies in transportation/transit across the region. Recommended strategies are based on a high-level assessment of market readiness across the region and of alignment with established goals for CONNECT Beyond.

The next section of the report indicates the potential for the identified categories of mobility innovation to advance the goals of the CONNECT Beyond project. This is followed by a more detailed **overview of eight key innovations in mobility technology and services,** which support the CONNECT Beyond goals and layers of mobility**.** For each innovation, the report offers a definition, key considerations based on recent research, and common implementation strategies appropriate for the CONNECT Beyond partners. These innovations are organized into the following categories, which are defined below:

Vehicle Technologies:

- **Autonomous vehicles and shuttles (AVs)** are vehicles that can operate with some level of operation control without driver input.
- **Connected vehicles (CVs)** are vehicles with technology that allow for vehicles and infrastructure to "talk" with one another. Connected vehicles can utilize Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and/or Vehicle to Everything (V2X) technology.
- **Electric vehicles (EVs),** both personal and shared, are vehicles that use one or more electric motors or traction motors for propulsion. In addition to electricity, vehicles may be powered by **alternative fuels** including gaseous fuels (hydrogen, natural gas, and propane), alcohols (ethanol, methanol, and butanol), and vegetable and waste-derived oils.

Shared Mobility Services:

- **Ridehailing** services are pre-arranged and on-demand transportation services for compensation in which drivers and passengers connect via digital applications (typically with booking, electronic payment, and ratings).
- **Microtransit** is defined as a privately or publicly operated, technology-enabled transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing.
- **Car share** offers members access to vehicles by joining an organization that provides and maintains a fleet of cars, vans and/or light trucks
- **Shared micromobilty** encompasses all shared-use fleets of small vehicles that are typically used to complete short trips.

Digital Platforms for Accessing Mobility:

- **Transportation or Mobility-as-a-Service (TaaS or MaaS)** is an open marketplace that maximizes personal mobility options by integrating a suite of available transportation options into a single platform with on-demand trip planning, real-time information, and payment.

Emerging Mobility in the CONNECT Beyond Region Context

Several existing mobility services, technologies, and initiatives, as noted below, indicate readiness for mobility innovations in the CONNECT Beyond project area. These services and initiatives, while not an exhaustive list of all regional mobility innovations, provide examples of the kinds of emerging mobility trends that are already present in the region and provide potential bases for expansion and implementation of other emerging mobility services to support CONNECT Beyond goals and recommendations.

- The **CONNECT Our Future Consortium**[1] is a partnership between Centralina and the Catawba Regional Council of Governments with a shared framework for regional growth. The framework identifies several tools to support mobility innovations, including Transportation Demand Management (TDM), Transit Oriented Development (TOD), alternative fuels and energy efficient vehicles, and complete streets.
- Centralina is also partnering with local, regional, state and federal agencies on **Regional Transportation Systems Management and Operations (TSMO) and**

[1] https://connectourfuture.org/about-connect/

Intelligent Transportation Systems (ITS) Architecture and Strategic Deployment Plans. The goal is an integrated regional effort to improve transportation reliability, safety, and access through the application of mobility technology innovations.

- **Vehicle technology** is a key focus area for Centralina. The **Automated and Connected Vehicle (ACV) Roadmap** (2018) introduces an action plan to navigate the integration of ACVs in the Centralina region with an eye on policy to support safety, mobility, and infrastructure health. The Roadmap illustrates a coordinated regional effort to anticipate autonomous and connected vehicle technology through near and long-term strategies.
- The **Centralina Clean Fuels Coalition** works with vehicle fleets, fuel providers, and stakeholders to promote the use of alternative fuels and advanced vehicle technologies in transportation through education, funding access, and public/private partnerships. With a combination of alternative fuels, electric/hybrid vehicles, and vehicle miles traveled/idle reduction initiatives, the coalition estimates a reduction of over 20,000 tons of CO2 each year. The Coalition tracks alternative fueling stations throughout the region, and currently reports 555 electric vehicle charging stations.
- Additionally, Centralina partnered with UNC Charlotte's Energy Production Infrastructure Center (EPIC), Eaton and Duke Energy to establish a current pilot project that will explore adding **electric vehicle charging technology to street light poles** at curbside locations.
- A range of local initiatives and projects being implemented in tandem with regional efforts. For example, the **City of Charlotte's Strategic Environmental Action Plan**[2] (SEAP) provides the blueprint for Charlotte to achieve ambitious goals of 100% zero-carbon energy sources for all City fleets and facilities by 2030, as well as becoming a low-carbon city by 2050 through substantially reducing greenhouse gas emissions.
- York County is now home to the **first microfactory of the U.K.-based zero-emission vehicle manufacturer Arrival**, with plans for producing electric buses at a new assembly plant in Rock Hill, SC.
- Rock Hill and Charlotte are putting **electric buses** into service, with Rock Hill's My Ride program introducing a 100% electric bus fleet.
- Charlotte, Rock Hill, and Gastonia have growing and maturing **shared micromobility fleets** (e.g., public bike share and scooter share systems).

[2] https://charlottenc.gov/sustainability/seap/Pages/default.aspx

Key Trends in the Mobility Sector

Over the last five years, **disruption has been the dominant trend** of the transportation sector. Disruption and new drivers of mobility change have ranged from mobility service providers operating within gaps in the regulatory and permitting structure (e.g. shared-ride services like Uber and Lyft) and the race to test autonomous vehicles, to smartphone applications that influence every aspect of choosing a travel route, mode, or form of payment. Figure 3 illustrates key implications that are shaping the mobility sector and decisionmaking about mobility.

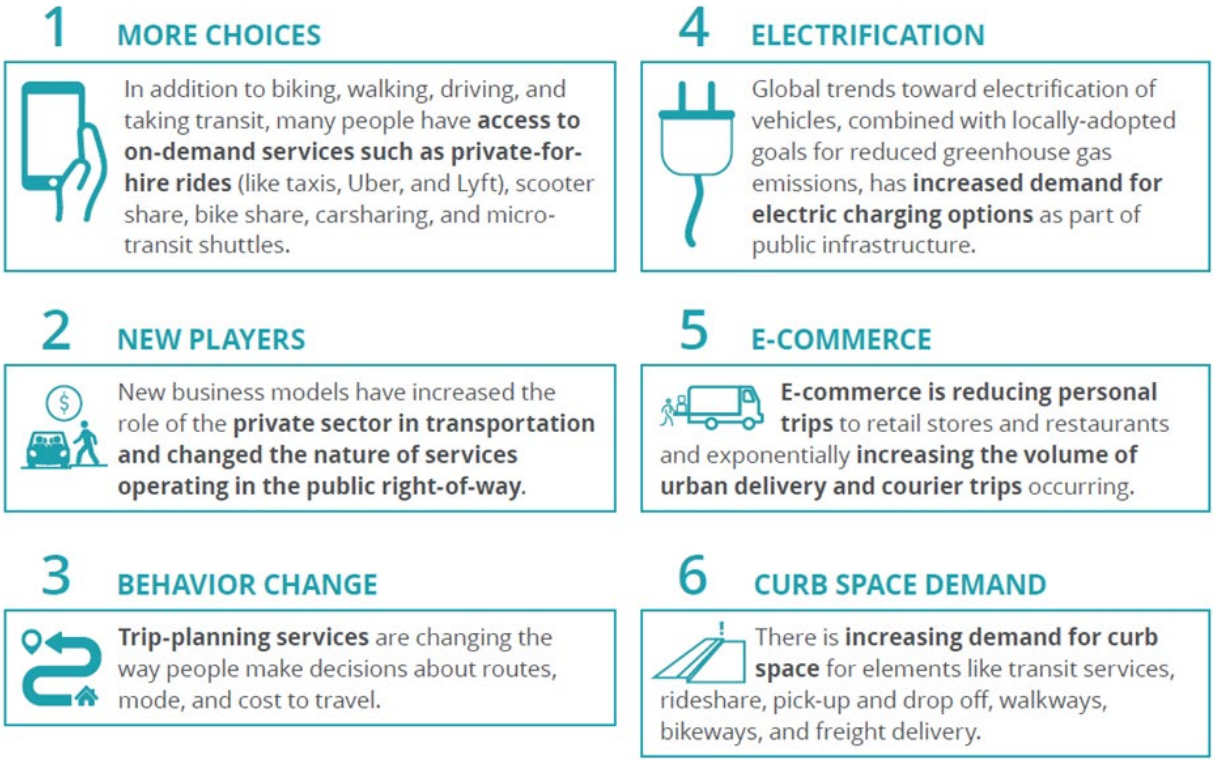

FIGURE 3. KEY IMPLICATIONS OF EMERGING MOBILITY TRENDS

While technological innovation offers a wide range of benefits and new opportunities for moving people and goods, expecting a sector dominated by long-term infrastructure investments and overlapping regulatory bodies to navigate rapid change is paradoxical. Uncertainty creates unique challenges for an industry that plans major projects decades in advance, relying on the data of today to indicate future travel needs. **The transportation**

sector -- at every level of government and including providers and consumers -- has gained new resilience through navigating these shifts.

During most of 2020 and into 2021, weathering the uncertainty of a pandemic and economic upheaval, required that transportation planners and policymakers apply the tools and strategies of this new resilience. **Both the public and private sectors have demonstrated a new capacity for being nimble and responsive, while also creating stability and reliability in mobility options.** For example, ridesharing services like Uber and Lyft have shifted more focus to food delivery and shared micromobility providers quickly adapted to the demands of the pandemic by providing disinfecting processes and adaptations for their vehicles. The public sector has provided new regulations and options for shared micromobility such as new options for organizing scooter and bike parking and plans for infrastructure to accommodate the expanded use of walking and biking and e-micromobility.

As a result, **the momentum of tech companies** who entered the transportation field with a philosophy of "move fast and break things" **has waned**. Public agencies have shifted focus and worked toward creative solutions that offer short-term outcomes, solving the immediate needs of the moment. Examples of this include expedited permits and fee waivers for outdoor eating areas, temporary car-free streets (or "slow streets"), free or reduced fares for commuting essential workers, and local business relief programs (visit CovidMobilityWorks.org for details of similar initiaitves across North America). This has led to a **change in the relationship of the public and private sectors** when testing and evaluating innovations. The companies and products that survived the last year did so by being relevant to the needs of the moment, partnering with public agencies, and responding to the actual (and shifting) mobility challenges of communities rather than working to siphon off profitable market segments. Many recent corporate investments reflects this, such as SPIN creating more equitable access to scootershare, Lime's newly designed adaptive bicycles, and Uber's positioning for public transit partnerships while divesting of autonomous vehicle technology developoment.

Emerging Mobility Strategies for CONNECT Beyond Region Partners

Recent shifts in the transportation sector and the growing prevalence of new transit/transportation modes and services are changing the way regions plan for mobility. This includes new approaches to existing planning tools, as well as new cross-cutting strategies intended to harness the benefits of new technologies and services while minimizing risk.

New Approaches to Existing Planning Tools

The following is a summary of new approaches to existing planning tools that are most relevant to the CONNECT Beyond region and partners:

- **Intelligent Transportation Systems (ITS)** has, for decades, pioneered applications of technology, communications, and information to improve transportation options, efficiency, safety, and operations. Multiple mobility innovations are integrated with ITS programs, including connected vehicle technology and mobility-as-a-service (MaaS). These tools expand opportunities to manage public transportation, personal travel options, freight and fleet management, and private mobility services.
- **Transit-supportive development** provides alternate approaches to achieving similar goals of transit-oriented development (TOD) in contexts better suited for low or moderate density development. CONNECT Beyond provides guidance for transit-supportive development strategies based on Community Development Character types that exist across the region. With emerging mobility innovations, this can include integrating flex fleets and flex services in transit, such as microtransit (Figure 4), planning for autonomous shuttles, or shared mobility partnerships.

FIGURE 4. ELECTRIC MICROTRANSIT SERVICE EMGO (EUGENE, OR)

- **Fleet administration and management** is an opportunity for public sector agencies to apply and scale new transportation technologies, including the potential to speed up the shift towards electrification. A 2021 survey[3] by the International City/County Management Association identified fleet administration and management as the number one service area ripe for alternative service delivery.
- **Joint procurement** is an agreement between agencies to purchase products or services through a shared solicitation and contract. For new and emerging innovations (e.g. electric buses), this approach has the potential to reduce prices through economies of scale and to boost the market (and reduce risk) for the companies investing in development.
- **Transportation demand management (TDM) programs** have new opportunities to incorporate digital tools to influence travel behavior particularly through employer programs. Examples include Hytch, which rewards commuters for choosing low-impact modes, and RideAmigos which automatically logs mode choice and provides challenges, games, and incentive programs for participating commuters (Figure 5). Share the Ride NC (STR NC) is a statewide TDM program that uses digital tools created by RideShark, a multimodal mobility management software provider. The CONNECT Beyond project provides a TDM framework, strategies, and action plan for the region.

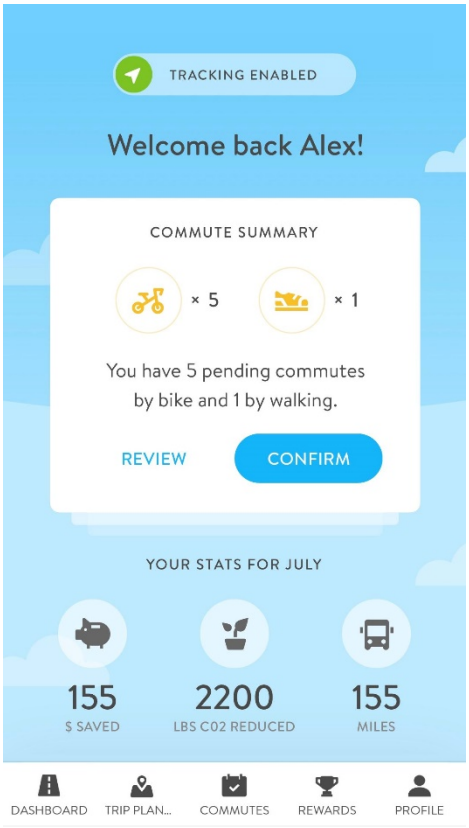

FIGURE 5. RIDEAMIGOS' COMMUTE TRACKING AND ENCOURAGEMENT DIGITAL PLATFORM

[3] https://icma.org/sites/default/files/Service%20Delivery%20Alternatives%20in%20the%20Age%20of%20COVID-19%20Summary%20Report_4.pdf

New and Expanded Strategies

The following are summary examples of new cross-cutting strategies that are occurring throughout the country that are most relevant to the CONNECT Beyond region and partners:

- **Broadband infrastructure** is increasingly being viewed as transportation infrastructure. NCDOT's I-70 and I-95 Innovative Technology and Rural Mobility Corridor Improvements project is one example. Funded by a USDOT INFRA Grant, the project adds hundreds of miles of broadband infrastructure across the state. This type of investment increases opportunities for using digital mobility tools/platforms by expanding access to high-speed internet across a larger geography. In the Centralina region, this may provide particular benefits in rural and low-density areas.
- **Curbside management** strategies balance competing needs for accessing the curb. Curbside management is a fundamental element of transit-supportive development and mobility hubs. The City of Charlotte is currently piloting the curbside management program Passport that provides data visualization and compliance monitoring tools. Curbside management is an important tool when co-locating mobility services, including multiple transit providers. With implementation of CONNECT Beyond strategies, these service providers will benefit from a coordinated approach to sharing a limited number of parking, pick-up/drop-off, or boarding/alighting areas in certain locations.
- **Mobility management** is a role that many transit agencies are considering pivoting towards. In some cases, the role would extend agencies' existing expertise and resources in operations, customer service, and network planning to apply to a multimodal suite of mobility services and service providers. In other cases, the role would largely involve data sharing agreements and/or subsidy programs. Coordinated strategies for mobility management in the Centralina region will be important as public and private mobility service providers establish new connections and partnerships to improve regional trip-making.
- **Mobility hubs** offer access to multiple transportation services in one location to improve multimodal trip making and accessing transit. Hubs are becoming a standard tool for region's readying for a future of increasingly diverse mode choices and service providers (Figure 6). In high density, urban context, mobility hubs are a tool for organizing and managing a wide range of public and private modes and services. In less dense and rural contexts, mobility hubs act as critical gateways to

economic centers and employers by providing consistent and reliable access to a more limited set of targeted mobility services (e.g. a regional express bus or a shuttle to high capacity transit lines).

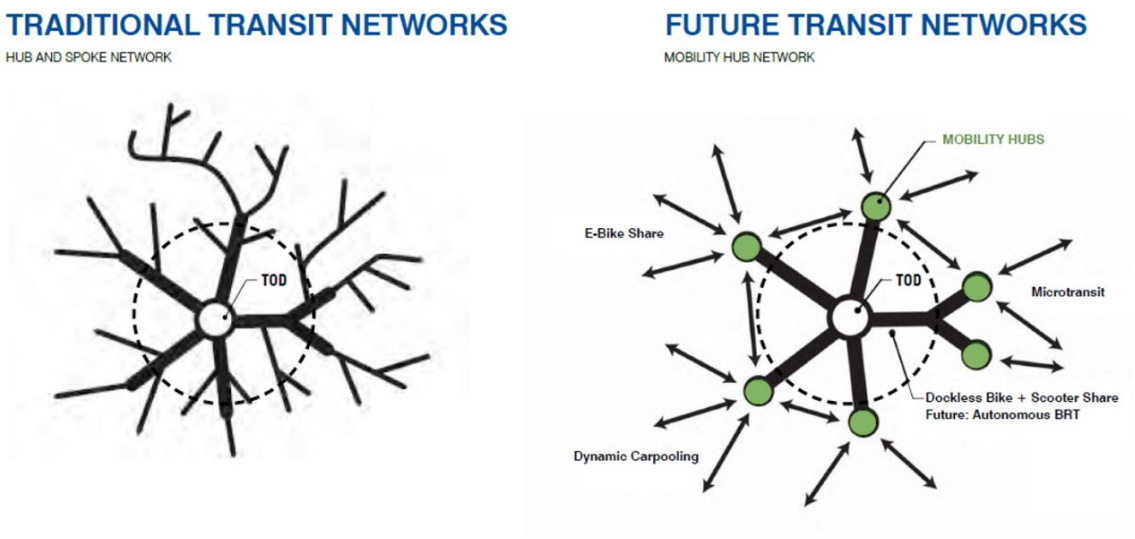

FIGURE 6. THE ROLE OF MOBILITY HUBS IN FUTURE TRANSIT NETWORKS

- **Microsubsidies** is a new term for rethinking how to advance equitable access to transportation when there are many different service providers. These would offer direct-to-individual subsidies for a multimodal, multi-provider mobility diet rather than subsidies to customers delivered through public or private service providers. This approach has the potential to better support regional travelers whose commute includes connections across multiple transit providers and/or a first- and last-mile mobility service (such as a vanpool or shuttle), as well as those whose schedule and travel needs frequently vary. Microsubsidies would remove the challenge of having varying types of subsidies and ways of accessing those subsidies with each provider and would give the commuter greater control of their transportation budget.

Nexus with CONNECT Beyond Goals

The CONNECT Beyond region has the opportunity to invest in mobility innovations that will advance regional goals. In relation to the CONNECT Beyond study goals and various layers of mobility, the region will need to consider how, when, and where to implement new and emerging transportation technologies and services so that they support the CONNECT Beyond Goals listed in Figure 7.

Table 1 indicates how each of the eight mobility innovations outlined in this memo relate to the CONNECT Beyond goal for developing action-oriented implementation approaches.

CONNECT Beyond Study Goals

- Define a single, coordinated transit vision for the project study area that includes multiple transportation modes.
- Identify high-capacity transit corridors that build upon and complement the Charlotte Area Transit System (CATS) 2030 System Plan and other regional and local transportation plans.
- Strategize on key topics and methods for regional coordination that cross modes of transit as well as organizational and geographic boundaries.
- Develop action-oriented implementation approaches that support:
    - Improved mobility and access.
    - Effective, regionally coordinated transit investments.
    - Coordinated and resilient transit operations to meet the needs of a growing and changing region.
    - Environmentally sustainable investments and policies.
    - Advancement of equitable and community-driven improvements.

FIGURE 7. CONNECT BEYOND STUDY GOALS

TABLE 1: MOBILITY INNOVATIONS AND CONNECT BEYOND OUTCOMES

	Improved mobility and access	Effective, regionally coordinated transit investments	Coordinated and resilient transit operations to meet the needs of a growing and changing region	Environmentally sustainable investments and policies	Advancement of equitable and community-driven improvements
Vehicle Technologies					
Automated Vehicles and Shuttles (AVS)	Autonomous buses and shuttles have the potential to expand the reach of transit.	AVs will collect rich data that can be used to monitor, manage and plan transit service planning and operations. Federal legislation may prevent local and regional agencies from accessing AV data, and companies that operate shared AVs may want to avoid sharing data with public agencies in order to protect competitive information about their services.			Autonomous buses and shuttles have the potential to enable transit service to expand its reach or improve service frequency to priority communities. Autonomous fleets may provide unique benefits to persons with disabilities and seniors.
Connected Vehicles	CV technology offers near-term opportunities to make transit more efficient and reliable.	CVs collect rich data that can be used to monitor, manage and plan transit service planning and operations.			CVs can improve traffic safety for people walking,
Electric Vehicles and Alternative Fuels				Reducing greenhouse gas emissions through use of electric and non- gasoline-powered vehicles provides direct environmental benefits. Fleet investments will hasten these benefits.	Improving air quality and resilience to climate change impacts benefits vulnerable communities who experience disproportionate effects.
Shared Mobility Services					
Ridehailing	Ride-hailing services offer a new way to travel, and have launched carpooling services in the region. Some transit agencies are subsidizing ride-hailing trips to transit stops in order to boost ridership. Most ride-hailing trips take place during the evening and on weekends, when transit service is less frequent, which suggests that ride-hailing and transit are complimentary. Ride-hailing fees collected by cities can be used to cross-subsidize other choices, like transit.			Ridehailing services increase total Vehicle Miles Traveled (VMT) and often replace trips that would have been made with a healthier transportation option. Converting ride-hailing vehicles to electric vehicles could produce significant environmental benefits, but electrifying a large share of ride-hailing vehicles requires a strong regulatory framework, as well as a significant investment in charging infrastructure.	Underrepresented groups in the user base include people of color, people with low incomes, and residents of suburban and rural areas. People who are unbanked, undocumented, limited English proficiency or lack access to the Internet also face barriers in accessing ride-hailing services. Users of the service are not representative of the general public. In spite of efforts to increase access, few ride-hailing vehicles are wheelchair accessible.

	Improved mobility and access	Effective, regionally coordinated transit investments	Coordinated and resilient transit operations to meet the needs of a growing and changing region	Environmentally sustainable investments and policies	Advancement of equitable and community-driven improvements
Microtransit	Because microtransit offers more flexible service, it could bring new choices to areas that are hard to serve with transit, including providing connections to transit stations that boost ridership.	Microtransit could provide better service at lower cost in areas with underperforming transit. It can also be a more cost-effective substitute for demand-response and special-needs transportation services. Additionally, public microtransit may complement rather than compete with existing transit services. However, in most pilot projects conducted to date, microtransit has cost far more per rider than fixed-route transit. In some cases, it has proved infeasible.	Unless the transit agency has full access to or control of the data produced by the application, this can create transparency issues.	Microtransit may not be as efficient as buses in terms of VMT and emissions because of more circuitous routes.	People who are unbanked, disabled, undocumented, limited English proficiency or lack access to the Internet also typically face barriers in accessing microtransit. Marketing to marginalized communities requires forming community connections. Some microtransit pilots offer phone-based bookings for people that do not have access to apps or the internet.
Car share	While car share provides residents with a new transportation choice, the industry has shown instability, leaving users without a transportation option they had come to rely on.		In many cases, car share services openly collaborate with public agencies in exchange for space or waived parking regulations.	Car share vehicles are more fuel-efficient than the average vehicle. People who do not own vehicles create less VMT. Stationary car share users, and to a lesser extent, free-floating car share users, drive fewer miles overall.	Without service area requirements, car share services focus on central neighborhoods that tend to be whiter and higher-income. People who are unbanked, disabled, undocumented, limited English proficiency or lack access to the Internet also face barriers in accessing car share. Electric car share pilots working to address these barriers by siting electric car share at affordable housing complexes have yielded mixed results.
Shared Micromobility	Shared micromobility is a tested solution for first/last mile access to transit. Bike share provides people with a new travel option and shifts trips away from driving. Scooter share appeals to people who might not otherwise try bicycles or bike share.	The public and private sectors have collaborated to develop standards and best practices for sharing, managing, and analyzing scooter data that support sound public oversight.	Traditional bike share systems are directly operated by public agencies, which often enables better oversight than permit-based bike- or scooter-share systems.	Scooter share shifts trips away from driving. Evidence from six cities indicates 33 percent-49 percent of scooter trips replaced driving trips. Scooter share provides a low-emissions alternative to driving for many trips. Electrification of scooter management vehicles could lessen emissions and VMT.	Bike and scooter share systems generally focus on serving central neighborhoods that tend to be higher-income. People who are unbanked, disabled, undocumented, limited English proficiency or lack access to the Internet can face barriers in accessing them. Scooter share often costs more per mile to use than bike share or transit.

	Improved mobility and access	Effective, regionally coordinated transit investments	Coordinated and resilient transit operations to meet the needs of a growing and changing region	Environmentally sustainable investments and policies	Advancement of equitable and community-driven improvements
Digital Platforms for Accessing Mobility					
Transportation/ Mobility-as-a-Service (MaaS)	Better travel information makes people more aware of their choices, and comprehensive information combined with competitive pricing could enable people to better identify the mode that works best for them.	Privately-operated MaaS sometimes directs people toward privately-operated services and away from shared and active options like transit and active transportation.			A MaaS-style system would help people identify the most affordable modes and enable public agencies to offer flexible subsidies to low-income and transit-dependent travelers that they could use to pick the mode that works best for them. Marginalized people frequently lack access to apps, data plans and the Internet. Without additional investment in digital access, underserved communities will not benefit from enhanced travel information.

Overview of Key Emerging Mobility Innovations

The following section includes an overview of eight key emerging innovations in mobility technology and services that are occurring throughout the country. For each innovation, the memo offers an overview of the technology, key considerations based on recent research and market updates, and common implementation strategies.

Vehicle Technologies

The rise of vehicle technology is poised to drastically alter the private and shared vehicle, freight, and public transportation systems, with major implications for safety, congestion, and air quality. This section covers the following three innovations in vehicle technologies:

- Autonomous vehicles and shuttles
- Connected vehicles
- Electric vehicles and alternative fuels

Autonomous Vehicles and Shuttles

Overview

Autonomous vehicles (AVs) are vehicles that can operate with some level of operation control without driver input. The National Highway Traffic Safety Administration has created a scale of automation for vehicles that allows drivers to know specifically how autonomous their vehicles are from '0' (no automation) to '5' (fully automated with no human interaction needed). Levels 4 and 5 automation require little to no driver interaction or intervention, and may not require equipment such as steering wheels (Figure 8).

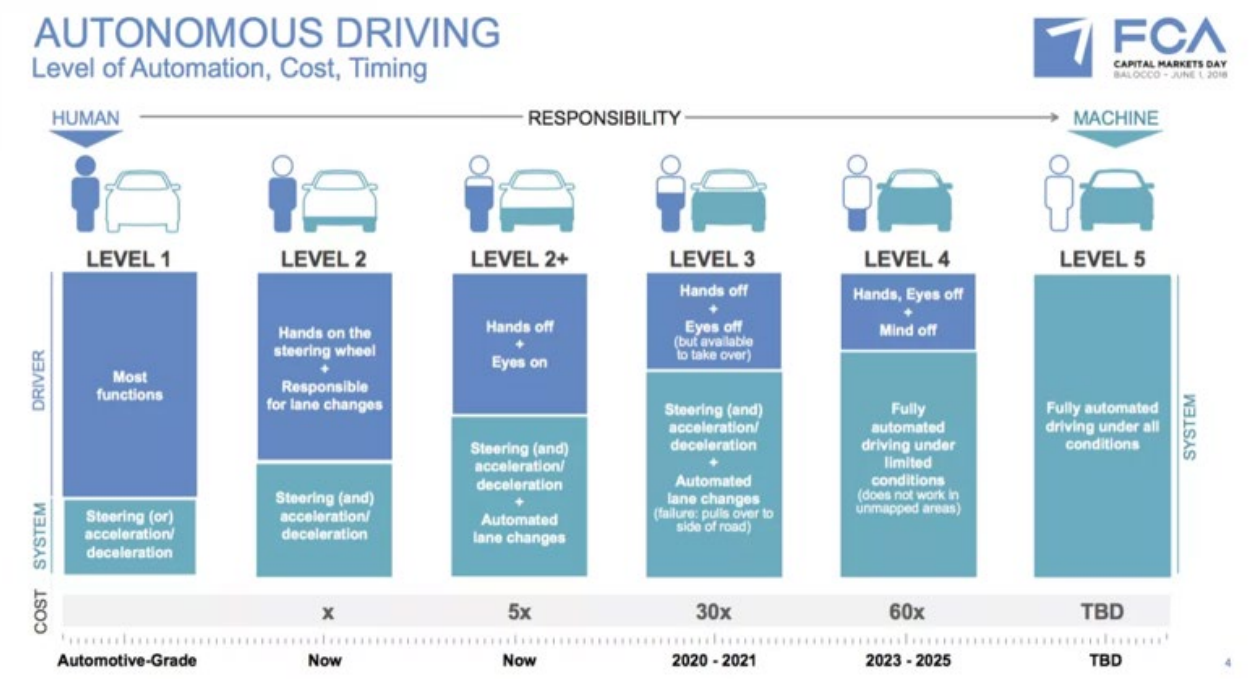

FIGURE 8. LEVELS OF AUTONOMOUS DRIVING TECHNOLOGY (SOURCE: FIAT CHRYSLER)

Autonomous vehicles continue to be tested in many states such as California, Massachusetts, Nevada, Texas and Arizona. There are a few small AV pilots in cities like Las Vegas and Phoenix of autonomous ridehailing services. Additionally, the majority of states have enacted some form of legislation and/or executive order related to autonomous vehicles (Figure 9).

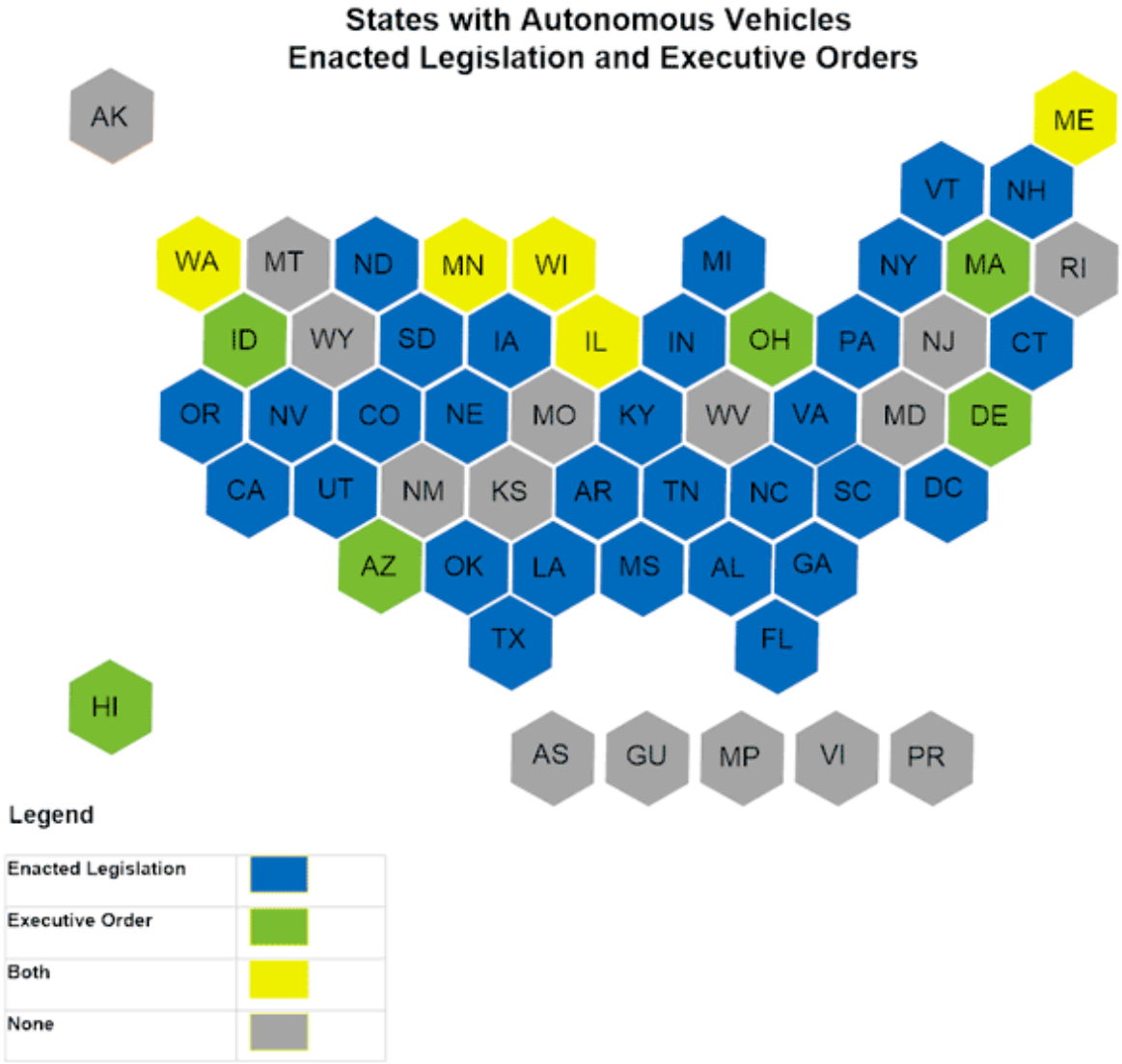

FIGURE 9. CONCEPTUAL MAP OF AV LEGISLATION BY STATE. SOURCE: NCSL.ORG

Multimodal streets like those found in regional centers are among the most complicated operating environments for AVs. With this in mind, many companies have shifted their roadmaps to accelerate long-haul freight, as freeway interactions are less complicated than urban interactions and the business models and use cases are more profitable. The COVID-19 pandemic and related economic downturn has slowed program development and investment in some AV technology but increased it in others, adding uncertainty to the pace of technology advancement and deployment timelines.

Autonomous vehicle considerations are included in the new MUTCD guidance currently under review and USDOT's 2021 AV Comprehensive Plan is providing a new level of specificity for national priorities/intention, but otherwise, AV deployment forecasts are more tempered than they were a year ago (i.e. 2050, with limited use-cases growing iteratively in both type and volume over the next 30 years).

Implications for Implementation for CONNECT Beyond Partners

- Cities currently have very limited regulatory levers to influence the implementation of autonomous vehicles. The federal government has regulatory purview of vehicle safety and state governments have regulatory purview of driver and vehicle licensing.
- Cities are considering regulations related to curb space management and vehicle occupancy as potential opportunities to ensure that autonomous vehicles reach their potential promise.
- Additionally, cities are considering the equity implications of AVs and how to make the new technology as accessible as possible.
- Cities are thinking about how to reduce demand for parking, congestion, and improve mobility with slow speed shuttles and how to support local businesses by partnering with AV drones.
- Several communities, companies, and institutions are working together on AV drones making medical or food deliveries to vulnerable populations. While regulations are limited, service provision partnerships are varied. It's also important to note that other agencies, in addition to cities, are testing AV and connected vehicle (CV) infrastructure.

Further Consideration and Applications

Autonomous technologies are being piloted in some small cities, non-urban contexts, and university campuses, including in North Carolina. The region would benefit from continued expansion of AV deployment, testing, and pilot programs. Examples include:

- **N.C. State's driverless shuttle (**Figure 10**)**: https://news.ncsu.edu/2020/02/driverless-shuttle-a-smart-move-for-centennial-campus/
- LSAV shuttle pilot program by Utah Department of Transportation and Utah Transit Authority: http://www.avshuttleutah.com/

- Valley Metro and Waymo partnership to explore first-and-last mile connections to transit in Phoeniz, AZ: https://www.azta.org/news/valley-metro-and-waymo-announce-transit-technology-partnership
- AV drone delivery of medical supplies in **Raleigh NC**: https://www.modernhealthcare.com/care-delivery/wakemed-health-hospitals-joins-forces-ups-faa-drone-pilot

FIGURE 10. NC STATE DRIVERLESS SHUTTLE PILOT CASSI (RALEIGH, NC)

Connected vehicles

Overview

Connected vehicles (CVs) are vehicles with technology that allow for vehicles and infrastructure to "talk" with one another. This allows for vehicles to be able to better predict and react to circumstances on the roadway as they change. Connected vehicles can utilize Vehicle to Vehicle (V2V), Vehicle to Infrastructure (V2I), and/or Vehicle to Everything (V2X) technology.

Connected vehicles have additional potential benefits compared to AVs because communicating with infrastructure would give vehicles additional information on which to operate. In particular, the potential for innovations with public transportation systems is strong, allowing public agencies to actively manage the transportation system and make transit more efficient and reliable. However, CV technology has not made much progress in the past several years. While USDOT has continued to pilot CVs and emphasize their usefulness, the Federal Communications Commission (FCC) has threatened to reallocate bandwidth that was previously set aside for vehicle to infrastructure communications. **Companies are increasingly focused on developing AVs that rely only on LiDaR, cameras and other onboard equipment to operate the vehicle.**

Implications for Implementation for CONNECT Beyond Partners

- Connected vehicles offer benefits in urban, suburban, and rural communities.
- Implementation strategies for connected vehicles focus on the installation of infrastructure such as roadside units (RSU) that serve as the communication devices between the infrastructure and the vehicles. Criteria for where and how RSU infrastructure is deployed is not standardized and varies by agency.
- For publicly owned fleets, such as transit fleets, most agencies also include onboard units to communicate real-time information to in-field and centralized infrastructure.
- Given the feasibility of on-board units for pedestrians and bicycles, some cities have begun to implement mobile phone applications that communicate real-time information from infrastructure such as signals to the user.

Electric vehicles and alternative fuels

Overview

Electric vehicles (EVs), both personal and shared, are vehicles that use one or more electric motors or traction motors for propulsion. An electric vehicle may be powered through a collector system by electricity from off-vehicle sources, or may be self-contained with a battery, solar panels or an electric generator to convert fuel to electricity. In addition to electricity, vehicles may be powered by alternative fuels including gaseous fuels (hydrogen, natural gas, and propane), alcohols (ethanol, methanol, and butanol), and vegetable and waste-derived oils.

The benefits of electric vehicles are well documented. However, a study from Portland State University found that, as expected, electric-vehicle ownership is concentrated among white

people and people with higher incomes.[4] The three most common barriers to electronic vehicle purchase that appear consistently in surveys are price, range, and infrastructure.[5]

Prior to COVID-19, electric vehicle sales had been rapidly increasing nationwide especially with advances in technology related to charging range. Electrification is still an upward trend across all modes with new innovations in charging infrastructure, including e-scooter/e-bike docking stations, and an uptick in investments in equity-focused EV carsharing programs, such as a program funded in St. Louis to provide EV rides for seniors, Boston's new Good2Go program (Figure 11), and the Twin Cities EV Spot Network in Minneapolis/St. Paul. The biggest strides currently in the market are related to business-to- business sales with the development of buses, semi-trucks, and delivery vehicles. Nearly every large delivery company has invested heavily in these new products (Amazon's electric vans are now making deliveries) with the promise of lower operational costs that will also deliver on sustainability goals.

Electricity is one of a many alternative fuels recognized by the U.S. Environmental Protection Agency. Others include hydrogen, biodiesel, ethanol, natural gas, and propane. Emerging fuels still under development or newly available in the U.S. include methanol, renewable hydrocarbon biofuels, dimethyl ether, and biobutanol.

[4] MacArthur, John, Ingrid Fish, Kelly Clifton, Joseph Broach, and Baxter Shandobil, Electric Vehicle Policies Targeting Low-income Drivers Would be Most Effective, New Report Finds, from Portland State University Transportation Research and Education Center, December 12, 2018.

[5] Halvorson, Bengt, Cost remains the biggest barrier against EV adoption, study finds, January 13, 2020. Retrieved from https://www.greencarreports.com/news/1126706_cost-remains-the-biggest-barrier-against-ev-adoption-study-finds

FIGURE 11. EV CARSHARING PROGRAM GOOD2GO (BOSTON, MA)

Implications for Implementation for CONNECT Beyond Partners

- Most local implementation strategies for electric vehicles have focused on supporting demand by **increasing the availability of charging stations**. Many cities have enacted requirements for private developments to pre-wire a certain percentage of parking spaces for EV charging, which significantly reduces the cost of installing charging stations later on and can help increase the supply of chargers in the long term.
- Additionally, Implementation strategies for electric vehicles focus on **increasing access to EVs in underserved communities**. Installation of geographically distributed charging infrastructure is a key initiative, in addition to subsidies, outreach and education, and electric ride sharing programs

Further consideration

A new funding measure introduced in the U.S. House of Representatives in March 2021 reflects the momentum of electrification trends. The Better Utilizing Investments to Leverage Development and Generating Renewable Energy to Electrify the Nation's (Build Green) Infrastructure and Jobs Act would provide $500 billion in grants administered by USDOT over the next decade to electrify public transportation, including rail systems, buses and fleet vehicles.[6]

Shared Mobility Services

Shared mobility services are transportation services and resources that are shared among users, either concurrently or one after another. Shared mobility services have grown tremendously over the past decade and include a wide range of modes and services which will be covered in this section:

- Ridehailing
- Microtransit
- Car share
- Shared Micromobility

Ridehailing

Overview

Ridehailing services are pre-arranged and on-demand transportation services for compensation in which drivers and passengers connect via digital applications (typically with booking, electronic payment, and ratings). These companies are commonly referred to as transportation network companies (TNCs).

The last few years have seen the ridehailing industry continue to grow, mainly through the growth of the two largest companies, Uber and Lyft. However, both companies remain unprofitable. This has led these companies to grow users through diversification of services and acquisition of other shared mobility services such as Jump, Lime, and Motivate. In addition to this, both companies have piloted offering services such as transit ticketing through their application. In one innovative pilot, the Charlotte Area Transit System (CATS) partnered with Lyft to provide discounts on Lyft rides that started or ended at two LYNX station areas, to encourage

[6] Source: https://thehill.com/policy/energy-environment/544061-ocasio-cortez-warren-introduce-bill-to-put-500-billion-toward?rl=1

first-and-last mile connections to transit. While these offerings may be akin to mobility-as-service, there is a fear amongst most cities that due to the closed nature of the applications and lack of coordination with local government these services will become "walled gardens"[7] that only contain information on a single company's services to drive people to use those services, rather than providing information on the full range of transportation options to help people choose the options that work best for their needs.

In the last year, the ridehailing industry has faced significant uncertainty. In an effort to make up for dramatic declines in ridership due to COVID-19, companies launched or expanded urban delivery services (e.g. Uber Direct and Uber Connect). While Waymo continues to pilot driverless taxis (Figure 12), Uber abandoned its program to develop AV ridehailing. These changes come as legal battles over labor laws continue and new research reinforces findings that ridehailing increases vehicles miles traveled and concludes that no future version of driverless ridehailing will improve that outcome.[8]

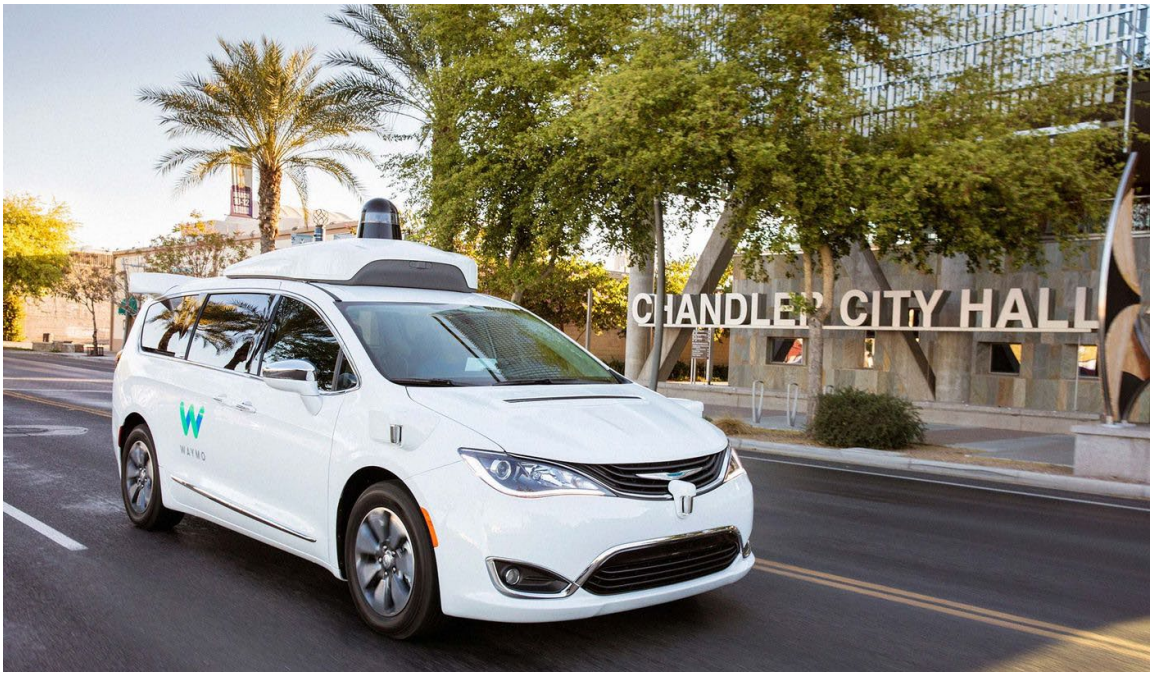

FIGURE 12. WAYMO'S DRIVERLESS RIDEHAILING SERVICE (PHOENIX, AZ)

[7] Fast Company, Why Uber and Lyft Want to Create Walled Gardens–and Why It's Bad for Urban Mobility, November 1, 2018. Retrieved from medium.com.

[8] Bruce Schaller, Can sharing a ride make for less traffic? Evidence from Uber and Lyft and implications for cities, Transport Policy, Volume 102, 2021, Pages 1-10, ISSN 0967-070X, https://doi.org/10.1016/j.tranpol.2020.12.015.

Implications for Implementation for CONNECT Beyond Partners

- Nationally, concerted efforts by transportation network companies to lobby for preemptive laws at the state level has limited local regulatory power in regards to ridehailing service and operations. Most cities have the limited ability to enact taxes and/or fees on rides originating or terminating in their jurisdictions which are used as a pricing tool to limit supply, demand, and congestion associated with these services.
- Ridehailing fees collected by cities can be used to subsidize other transportation choices like transit[9], and some transit agencies are subsidizing ride-hailing trips to transit stops in order to boost ridership.[10] The administrative mechanisms for collecting fees varies. For example, the City of Chicago used an existing Ground Transportation Tax to assign a per trip charge when a TNC ride begins or ends within city limits (and higher charge when it begins/ends in downtown). In California, the state's Public Utilities Commission (CPUC) requires TNCs to collect a ten cent ($0.10) fee on each trip within the state to support the expansion of on-demand transportation for non-folding wheelchair users who require a wheelchair accessible vehicle (WAV).

Further Consideration and Examples of Applications

Examples of ridehailing programs structured as a complement or alternative to transit service include:

- The Charlotte Area Transit System (CATS) just concluded a pilot program with Lyft to provide discounts on Lyft rides that started or ended at two LYNX station areas, to encourage first-and-last mile connections to transit.
- RTP Connect is a last-mile option offered by Go Triangle in Research Triangle Park, NC: https://gotriangle.org/rtpconnect
- Go Monrovia is a ridehailing partnership to subsidize a transit alternative in Monrovia, CA: https://www.cityofmonrovia.org/your-government/public-works/transportation/gomonrovia

[9] Lutenegger, Brian, Chicago to use TNC fees to improve 'L' service, February 26, 2018, State Smart Transportation Initiative. Retrieved from ssti.us.

[10] For examples, see New York Public Transit Association, Transit & TNCs, n.d. Retrieved from nytransit.org.

Microtransit

Overview

Microtransit is defined as a privately or publicly operated, technology-enabled transit service that typically uses multi-passenger/pooled shuttles or vans to provide on-demand or fixed-schedule services with either dynamic or fixed routing. Riders generally connect to the provider using a smartphone app, but unlike ridehailing operations, rides may be available on-demand or the company may offer fixed-schedule services. Similarly, these shuttles can have either dynamic or fixed routing.

While most microtransit firms started up around 2014, it is not a completely new innovation. Instead, microtransit uses recent technology (such as on-demand routing software) to enhance an existing mode – the shared shuttle service or "Dial-A Ride" program. While many older services respond directly to rider requests, the use of technology enables microtransit services to track and respond to demand in real time, providing responsive service. **This technology can be useful for commuters as a first- and last-mile transportation strategy and also for transit riders with disabilities who need assistance getting to and from stops and stations**. It may also be of interest to historically-marginalized communities or in rural/suburban contexts where transit service is limited in frequency, geographic reach, or presents time gaps.

Microtransit and flexible fleets have had mixed success (or flat out poor results) to-date but the changes to transit ridership in the last year have increased appetite for figuring out flexible service and fleet solutions, and will likely remain part of the conversation in first- and last-mile and mobility hub planning.

Implications for Implementation for CONNECT Beyond Partners

Cities and transit agencies have been the main implementers of microtransit through contracting with private companies. The success of public microtransit services has been highly dependent on the quality of service versus the alternatives, transfer costs, and marketing. Other important factors include the size of designated service area(s), the density of these areas, and the target population.

Larger cities such as Seattle, Denver, Sacramento, have experienced success in microtransit under particular circumstances. In Denver, the transit agency chose service areas where providing shuttles has been more cost-effective than comparable bus service. Their microtransit ridership has been especially consistent in first mile/last mile areas that serve

office parks or colleges. Sacramento's SmaRT microtransit service had the goal of providing underserved, disadvantaged, less-dense communities with connections to the greater transit system. SmaRT has been successful enough to expand service hours and regional coverage while still seeing an increase in productivity, and is a good blueprint to consider for the CONNECT Beyond region. They have, at the same time, struggled with longer-than-ideal wait times.

Additionally, a number of small and rural communities have developed microtransit pilot programs, including:

- RIDE (serviced by Via), the City of Wilson, NC's microtransit service that replaced the fixed-route bus system in late 2020 (Figure 13): https://ridewithvia.com/resources/multimedia/the-city-that-brought-microtransit-to-rural-america/
- Lane Transit District's mobility-on-demand program in Cottage Grove and Eugene, OR: https://blog.transloc.com/press/lane-transit-district-partners-with-transloc-for-agency-owned-microtransit-pilot-program

FIGURE 13. RURAL MICROTRANSIT SERVICE RIDE (WILSON, NC)

However, **not all public microtransit programs have proven successful**.

- The collapse of Kansas City's RideKC project was attributed to poor marketing of the program and its discount promotions, as well as a lack of understanding of travel patterns and customer needs.
- In Santa Clara County, Valley Transportation Authority (VTA) ended their mictrotransit pilot due to high operating costs and low farebox revenue. This service manages only 0.4 boardings per hour over their six-month operation, compared with VTA's usual minimum of 15 boardings per hour.
- The Salem, OR Area Mass Transit District (Cherriots) experienced failure with its on-demand shuttle pilot (called the Connector), which started in June 2015. Due to this failure, the Connector was converted back to fixed-route buses in January 2018.
- Nationally, some large private microtransit operators like Ford's Chariot have ceased operations, while others such as Via have thrived in the last two years.

Factors that agencies and researchers reported to contribute to success in public microtransit operations or partnerships include:

- Designating service regions that have suitable characteristics (such as lower-density residential areas but enough demand)
- Avoiding redundant service provision
- Including established "checkpoints" where shuttles always stop (such as a transit station or shopping center)
- Focusing on providing equitable access for low-income riders, people with disabilities, and those with limited English proficiency (through wheelchair access, translation services, and a range of trip options)
- Robust marketing and outreach to target population
- Setting performance metrics that are not limited to ridership and revenue (but also including improvements in mobility, safety and customer experience)
- Setting contract terms with private contractors carefully to ensure public and agency needs for transparency are addressed
- Getting around slow bureaucratic processes and empowering those working on the program to iterate quickly in response to failure

From the varied experiences of public microtransit services, it is clear that **careful planning, targeting, marketing, testing, and adjustment are a necessary component of these**

programs. With the loss of transit service due to budget cuts associated with COVID-19, transit agencies may take a closer look at microtransit to provide lower operational costs for low-ridership areas or highly focused services such as essential workers. Pilot programs have potential to explore these opportunities further.

Car share

Overview

Car share offers members access to vehicles by joining an organization that provides and maintains a fleet of cars, vans and/or light trucks. The organization typically provides insurance, gasoline, parking, and maintenance, and members typically pay a fee each time they use a vehicle.

There are three types of car sharing services: free-floating (Car2Go, etc), peer-to-peer (Getaround,Turo), and point-to-point (Zipcar). Free-floating car sharing was available and widely used in many US cities until 2019, when the two largest companies- Reach Now and Car2go- merged and then ceased operations in North America. Station-based, point-to-point car sharing still exists in many cities, as does peer-to-peer car sharing, but with services such as Zipcar, they do not provide the convenience of free-floating car share as they are not a viable option for one-way trips.[11]

The car share industry has been largely quiet over the last year, though peer-to-peer programs saw a jump in usage/membership in response to COVID-19. Cities want more EV car share programs for low-income communities, and it is **speculated that free-floating car share (like Car2Go) may return to North America** after its unexpected withdrawal in late 2019.

Implications for Implementation for CONNECT Beyond Partners

- Free-floating and point-to-point car share have typically been permitted by cities and have been regulated by some states.[12] These permits typically include terms related to distribution of vehicles, service levels, and parking requirements/fees in addition to typical administrative requirements such as insurance and indemnification.
- Peer-to-peer car share has not been permitted by cities, but some states have enacted regulations including minimum insurance requirements and restrictions on

[11] Neiss, Michelle; Szamborski, Eddie. Regional Travel Options Survey Summary. DHM Research. October 29, 2019.
[12] National Conference of State Legislatures, Car Sharing – State Laws and Legislation, January 14, 2020.

revenues from exceeding the annual expenses of a personal vehicle used on a peer-to-peer car sharing platform.[13]

- Some public agencies have directly funded electric vehicle sharing though systems like BlueLA in Los Angeles, where a public-private partnership between the City, the State of California, and a private company provides affordable, publicly-available shared EVs and chargers in public locations throughout the city. In other cases, such as Sacramento's partnership with Envoy, the City and State fund private stationary EV share at affordable housing developments. In 2018, Hacienda CDC and Forth partnered on a pilot program to cite electric car share vehicles at affordable housing apartment complexes in the Cully neighborhood in Portland, OR. The program highlighted the potential mobility and economic benefits this type of partnership can provide, but also identified challenges related to insurance, banking, a lack of driver's licenses, and outreach that would need to be addressed for the sustainability of this model.[14]

Further Consideration

Community-supported car share programs tailored to local needs and supported with grant funds may be most appropriate in small urban and low density communities. MioCar in California's San Joaquin Valley is an example (Figure 15): https://miocar.org/

[13] Ibid.

[14] Teebay, Catherine, Electrifying Community Car Share, June 28, 2018, Forth. Retrieved from forthmobility.com.

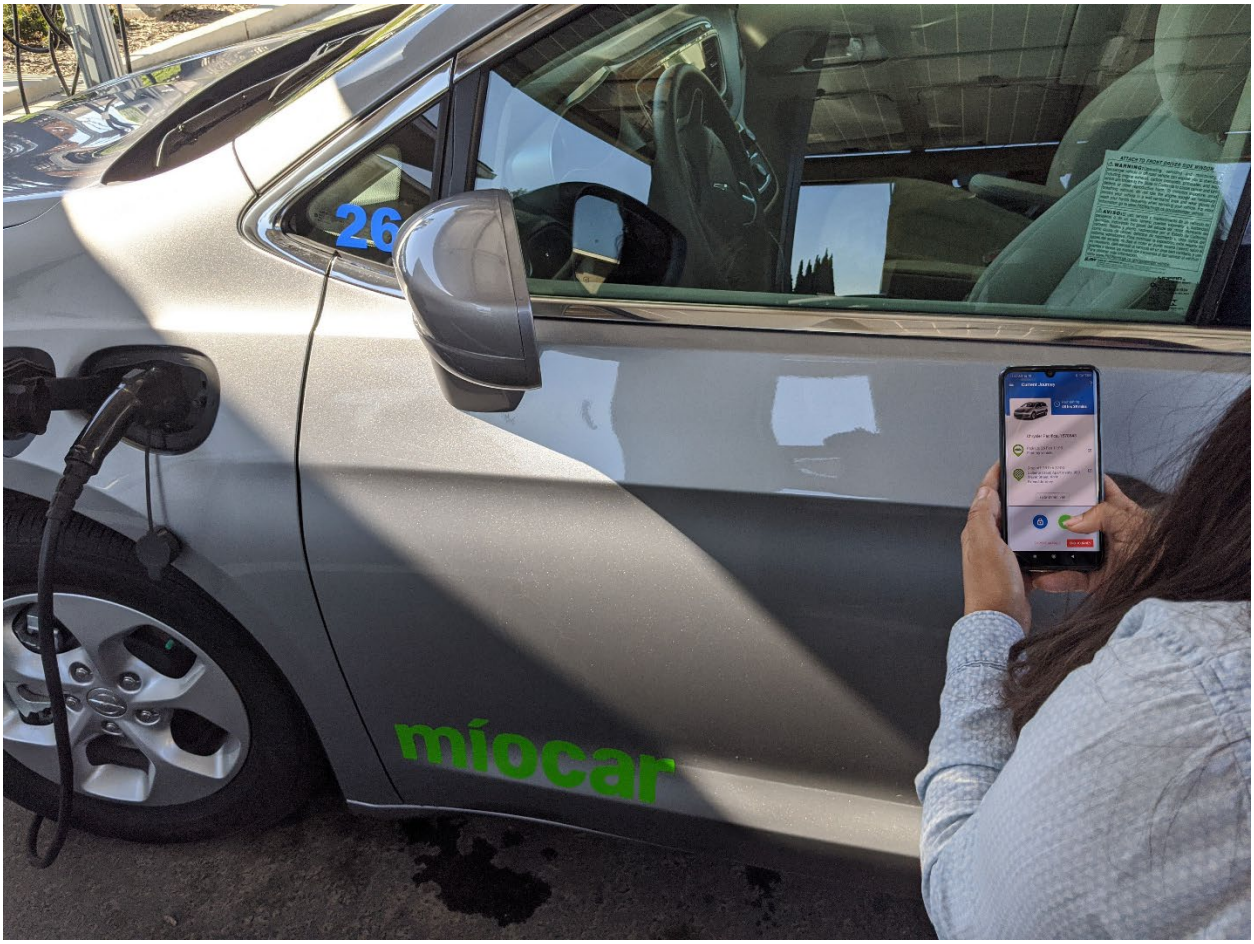

FIGURE 14. EV CAR SHARING SERVICE MIOCAR (SAN JOAQUIN VALLEY, CA)

Shared Micromobility

Overview

Shared micromobilty encompasses all shared-use fleets of small vehicles that are typically used to complete short trips. Bike share provides users with on-demand access to bicycles (both conventional and electric) at a variety of pick-up and drop-off locations for one-way (point-to-point) or roundtrip travel. After a massive expansion in 2017 and 2018, dockless pedal (non-electric) bike share systems were removed from many American cities. The remaining systems are typically station based (including hybrid systems) or dockless electric-assist systems. Scooter share allows individuals access to scooters by joining an organization that maintains a fleet of scooters at various locations. This can include a variety of motorized and non-motorized scooter types. Organizations typically provide gasoline or charge (if motorized), maintenance, and in some cases parking. Users typically pay a fee each time they use a scooter and some

companies are starting to test monthly rentals. Moped share allows individuals to join an organization that maintains a fleet of mopeds at various locations. Initial applications have been electric and organizations typically include the cost of fuel, maintenance, and in some cases parking in their price structure. Users typically pay a fee each time they use a moped.

Shared micromobility has only increased in relevance, though the market has bifurcated (major city vs not), with micromobility providers and support industries continuing to innovate vehicle type/technology and business/operations models. Curbside management continues to be an area of focus with an increased need to balance the demand between ridehailing pickup and dropoff, parking for shared micromobilty devices, and the rise of e-commerce and delivery (Figure 15).

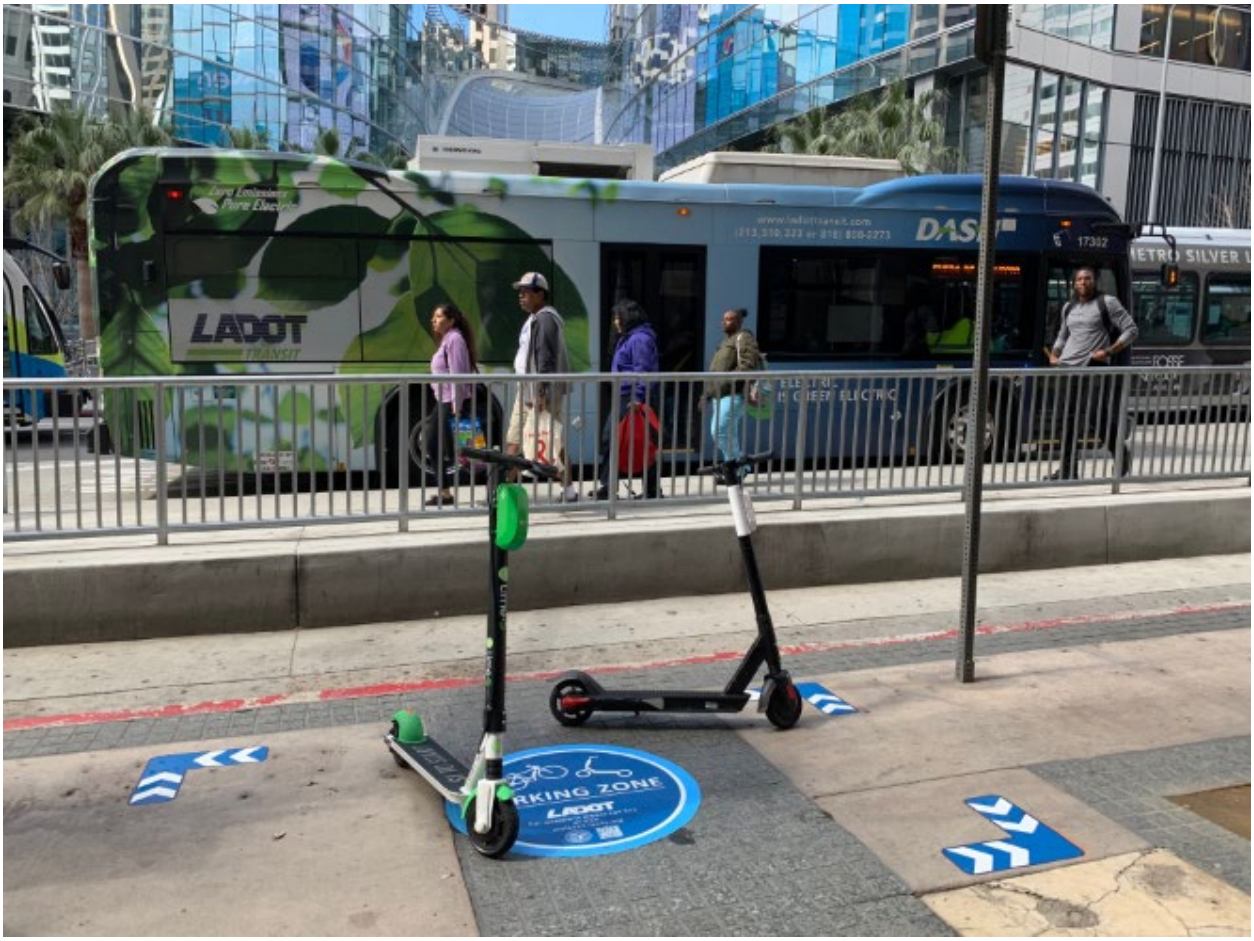

FIGURE 15. DESIGNATED CURB SPACE FOR SCOOTER PARKING (DOWNTOWN LOS ANGELES, CA)

Implications for Implementation for CONNECT Beyond Partners

Shared micromobility systems have typically been permitted by cities, often on a pilot basis where cities offer limited duration permits, evaluate usage and compliance under those permits, and then revise permitting requirements. These permits typically include terms related to distribution of vehicles, service levels, equity requirements, parking requirements, and administrative fees in addition to typical requirements such as insurance and indemnification.

Alternatively, many cities contract with bike share providers for direct service provision. This model provides cities with a higher level of control as they negotiate the contract with requirements that dictate most aspects of the system, including:

- Station locations
- Bicycle and station equipment
- Pricing structure for users
- Equity programs
- Service levels

Right now, scooters have no upfront cost, while bike share requires significant investment and public subsidy in most markets. With the shift in the micromobility business model, some cities have begun to consider exploring a concession agreement or contract model rather than permit. This model would offer exclusive rights to the service with potentially some city funding and allow cities to select companies based on proposed and prior performance.

Further Consideration and Example Applications

Shared micromobility programs have been successful in a wide range of small cities and college campuses, such as in Rock Hill, SC, Gastonia, NC, Spartanburg, SC, and Charlotte, NC. The City of Charlotte uses dynamic pricing as an incentive for proper scooter operation and parking procedures, a cost that scooter companies can either bear or pass along to the user.

Digital Platforms for Accessing Mobility

With the emergence of myriad transportation options and services, digital platforms that help users navigate transportation choices are essential. This section explores Transportation/Mobility as a Service (TaaS/MaaS), a concept that is still in its infancy but will play an increasingly critical role as the complexity and customization of transportation services continues to grow.

Transportation/Mobility-as-a-Service (TaaS/MaaS)

Overview

Transportation or Mobility-as-a-Service (TaaS or MaaS) is an open marketplace that maximizes personal mobility options and reduces reliance on privately-owned vehicles. MaaS enables seamless end-to-end journeys by integrating a suite of available transportation options into a single platform with on-demand trip planning, real-time information, and payment (Figure 16).[15] Higher levels of MaaS include bundling of services and subscriptions, and integrating policy to support usage of MaaS systems. MaaS is a critical tool for integrating multiple providers and modes into one cohesive system, and comprehensive information combined with competitive pricing can enable people to better identify the mode that works best for them.

No full MaaS system exists in the United States currently, like the Whim app in Finland, but many services are integrating payment, wayfinding, and multimodal offerings to create mobility on demand platforms for users.

[15] Oregon Department of Transportation, Mobility as a Service (MaaS) in Oregon, May 2020. Retrieved from: https://www.oregon.gov/odot/Planning/Documents/MaaS%20White%20Paper%20Final%205-13-2020.pdf

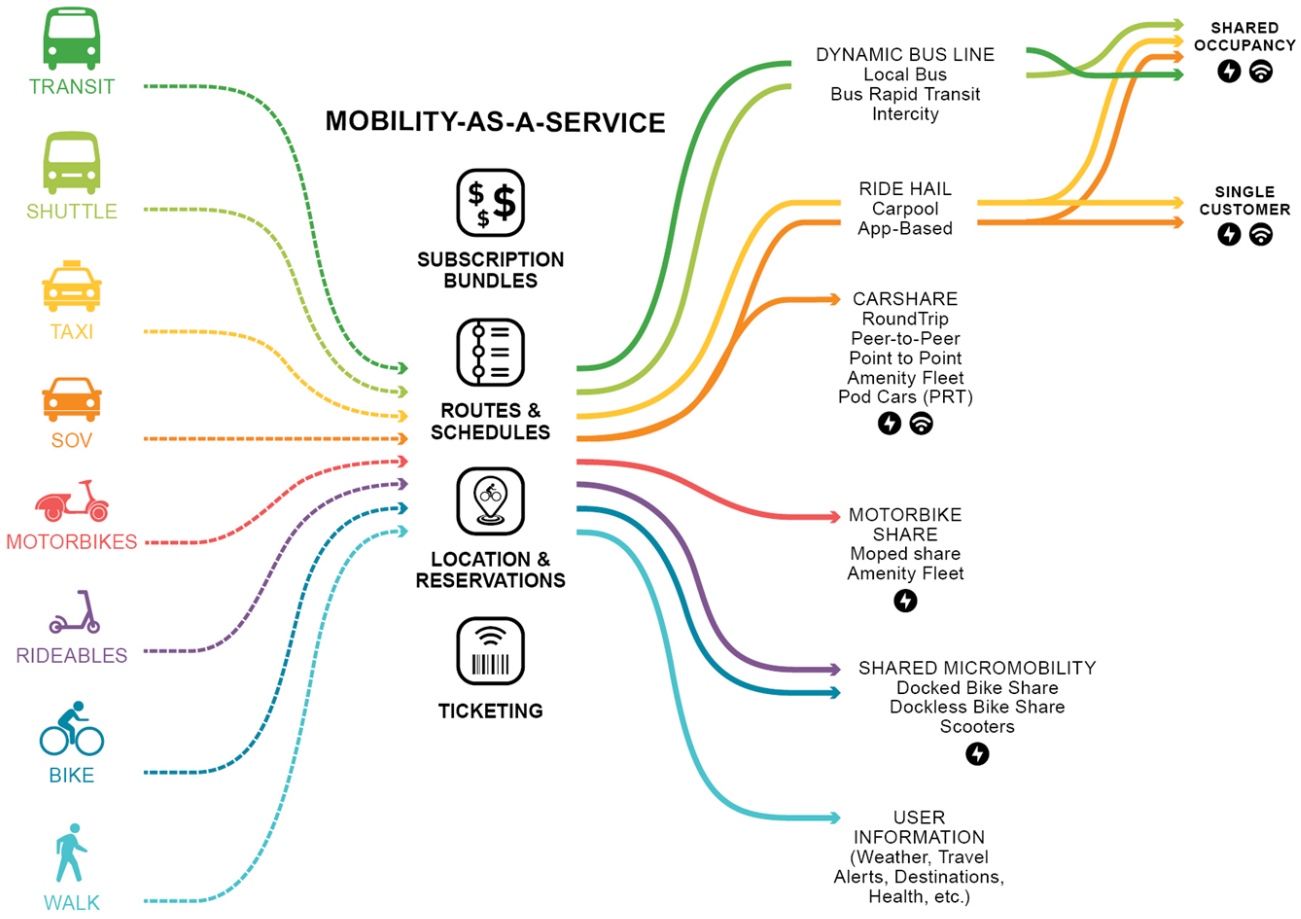

FIGURE 16. MOBILITY-AS-A-SERVICE AND THE INTEGRATION OF TRAVEL CHOICES

Implications for Implementation for CONNECT Beyond Partners

- The MaaS industry is still in its infancy without a true implementation in the United States. However, Mobility-as-a-Service remains a popular concept, with the public sector wanting to understand what their potential role/local opportunity is and how to focus MaaS development on advancing equity and climate change goals; while the private sector is launching new MaaS products (like Umo and Bytemark) and working to overcome the significant hurdles to seamless payment integration.
- The local potential of MaaS is limited by the lack of multimodal transportation options in many parts of the CONNECT Beyond region, but there is potential to use

MaaS to support sustainable and affordable transportation choices as new transportation options become available in the area.

- The Pittsburgh Mobility Collective is one of the most advanced pilots in this space with the potential of offering **car share, carpool, scooter share, bike share, and transit services both from public and private operators in one application**.
- Another potentially innovative approach to MaaS is providing a **mobility wallet** which would allow third parties such as employers or housing developers to purchase MaaS bundles for users in exchange for regulatory exemptions on taxes or parking. The City of Portland recently piloted a mobility wallet program for residents of affordable housing. https://www.portlandoregon.gov/transportation/78475
- Digital tools like Routematch may provide a near-term option for developing MaaS-like programs in the CONNECT Beyond Region: https://www.routematch.com/mobility/