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DESIGNING FOR FUTURE MOBILITY:
Developing a Framework for the Livable Future City

Aaron Knorr, RA, LEED AP, *aaron.knorr@perkinswill.com*

ABSTRACT
We are experiencing a technologically-driven shift in the transportation industry, which is transforming the way we move and live in cities. While new mobility options have the potential to profoundly change the way that we plan, design, and build transportation infrastructure, the impacts of these technologies on livability and urban design are not well understood.

This study aimed to define future mobility principles that support livable city goals through a series of proactive, present-day design opportunities for planners, designers and policy-makers. The research was based on an extensive literature review of current trends, projections and impacts in the realm of urban transportation, and livable city criteria. A series of principles and design opportunities, informed by this research, have been identified to help shape the implementation of design decisions towards positive livable city outcomes.

It is critical that we take the initiative to understand and shape the future of mobility in a positive and purposeful way. The conclusion of the study is that we need to re-frame the approach to disruptions in mobility by focusing on people and the type of city we aspire to, and determine how future mobility technologies can help support this vision.

KEYWORDS: autonomous vehicles, self-driving cars, transportation, mobility, urban design

1.0 INTRODUCTION

When automobiles were first introduced to cities in the early twentieth century, urban rights-of-way were heterogeneous spaces shared between pedestrians, bicycles, horse-drawn carriages and trolleys. Within just two decades, roadways had been almost completely given over to the new “horseless carriages” and the car had radically changed the way that we inhabit and design our cities and regions— including many impacts that have been detrimental to the human, ecological, experiential and equitable health of our communities.

Today, we are on the threshold of a similarly transformational change in the way we move, and live, in urban areas. Disruptions now underway in urban mobility are likely to usher in the most significant changes to cities that we will see in a generation.

Public officials, planners, engineers and other city builders are recognizing that it is critical to meet these potential impacts head on. What is less clear is how to respond to such an undefined, indeterminate, and unknown set of circumstances. This study evaluates the most important emerging trends in urban mobility, how those shifts are likely to impact the way we design cities, and proposes a set of guiding principles and areas of focus to begin shaping the future of mobility today.

2.0 CURRENT TRENDS IN URBAN MOBILITY

We are witnessing an exponential growth in several technologically-driven shifts in the transportation industry today, each with the potential to dramatically upend the way we get around cities. For the purpose of this study, these trends have been broadly organized into four major categories, as shown in Figure 1.

Figure 1: Trends in urban mobility.

2.1 Self-Driving Vehicles

Self-driving vehicles have been getting a lot of attention, capturing the imagination of planners and the public alike. Technology that allows vehicles to navigate themselves, without a human behind the wheel, has been decades in the making[1]. Over the last five years, autonomous technology has gained significant traction with improvements to sensory and mapping technology, an influx of new industry players, and significant investments across the private and public sectors.

Proponents of fully autonomous vehicles suggest a broad array of benefits to society, including reduced mobility costs, greater convenience, and a dramatic reduction in the number of traffic collisions and related fatalities. There is still much debate about how the widespread use of self-driving vehicles might affect road congestion, travel behavior, and settlement patterns resulting from the ability for users to make more productive use of travel time.

Today, there are vehicles navigating urban roadways that have achieved various levels of conditional automation—allowing for the vehicle to assume full responsibility for navigation under certain circumstances. While current applications are largely limited to test pilot projects, it is expected that the number of self-driving vehicles on city roads will accelerate in the near term. In fact most of the largest automobile manufacturers and tech companies have committed to making fully autonomous vehicles available on the market within the next five years[2]. How soon and to what extent the technology becomes widely available is still very much an open question and will largely depend on the resolution of technological, safety, and regulatory concerns.

2.2 Networked Transportation

Mobile phones, apps, and the vast communication network that supports their use are quickly becoming important tools used for moving around cities. In the same way that these devices have transformed the way that many people consume media, goods, and services, mobility is similarly evolving to become an on-demand service. Decisions about how to get from points A to B are increasingly being made with the assistance of networked devices that also enable users to make payments, compare options, and plan routes.

An entire industry of transportation network companies ("TNCs", e.g.: Lyft, Uber, etc.) has emerged, providing on-demand rides by connecting drivers and passengers via mobile apps. Such services have been steadily gaining in popularity, as seen in Figure 2, particularly in the densest areas of population and employment, and

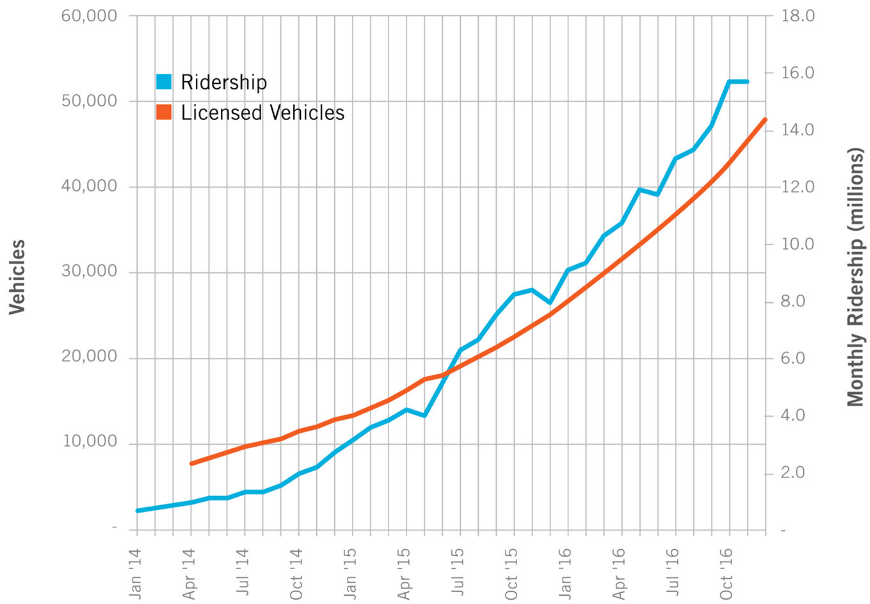

Figure 2: Use of ride hailing services[5].

largely for trips that are relatively short in length and duration[3]. However, studies in cities where ride hailing has become widespread suggest that their use has resulted in an increase in the number of vehicle trips made and distance traveled, often at the expense of public transportation and other shared or active modes[4].

The use of networked platforms has also resulted in the creation of immense amounts of data, available in real-time, about how and where trips are made—with great potential for assisting in the planning of transportation services.

The rapid growth in adoption of mobile technologies and their use for planning day-to-day travel is expected to continue and to accelerate with the growth of mobility as a service (MaaS), which has the potential to link different modes of travel together on the same digital platform to integrate movement and ease of payment across many different mobility providers (both public and private) with a single account as an on-demand or subscription service.

2.3 Shared Mobility

Largely as a result of the benefits offered by networked access to mobility options, an increase in the use of shared transportation modes is making it more convenient and more affordable for many people to access mobility services on an as-need basis instead of through ownership. This is most clearly observable in the emergence of car sharing, bike sharing, dockless scooters, and ride hailing services in many cities and the uptake in these shared modes for trips[6].

The shift towards shared instead of privately owned transportation modes offers significant opportunities for city planning. While privately owned vehicles sit unused roughly 95 percent of the time, shared modes result in a much more efficient utilization of a vehicle fleet with a corresponding reduction in the number of cars and storage space needed to deliver the same number of trips within cities.

Vehicle sharing programs have been most successful in densely populated areas serviced by multiple transportation options. For users that do not rely on driving daily, vehicle sharing has proven to be a less costly alternative to car ownership and operation[7]. Since the beginning of the 21st century, there has been a general trend across most age demographics towards fewer people obtaining a driver's license, and a lower likelihood to purchase a car than in the past (Figure 3). Studies indicate that people who participate in vehicle sharing programs are likely to sell their vehicle or delay purchasing one, and tend to use public transportation more often while relying less on driving overall[8].

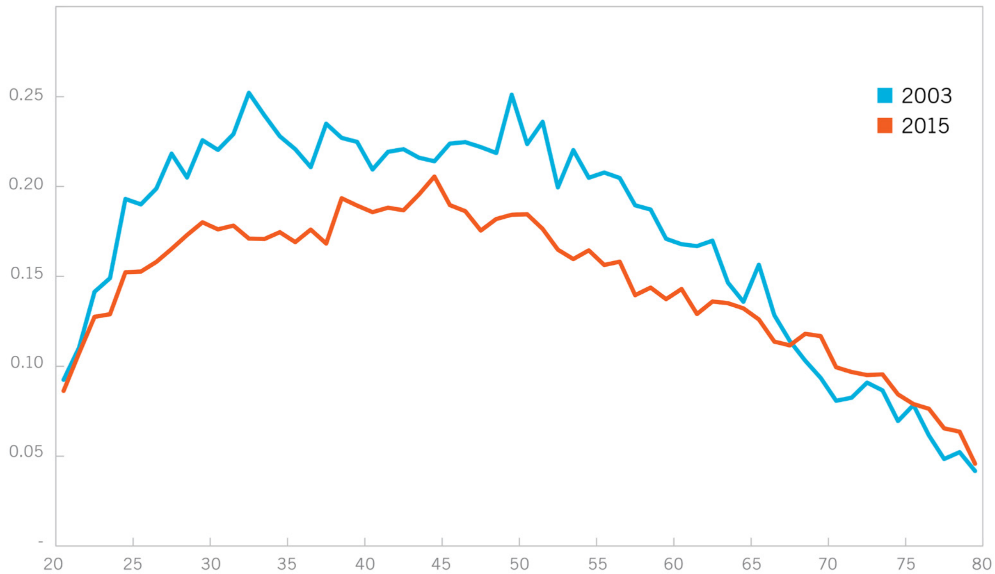

Figure 3: Car loan originations per capita, by age[9].

2.4 Electric Propulsion

The movement of people and goods today are predominantly powered by petroleum-based fuels, which account for a significant percentage of greenhouse gas emissions in North America. However, steady improvements in the range and performance of electric vehicles have accelerated a global shift towards cleaner forms of mobility.

While electric vehicles represent less than one percent of total vehicles purchased, their total number of sales has gone from less than 100,000 five years ago, to over 2 million globally in 2016, including a 60 percent year-over-year increase in the last year[10]. If coupled with improvements in the broader energy grid, these shifts could dramatically reduce carbon emissions from the transportation industry and improve air quality in cities.

The shift to electric vehicles will likely be accelerated by recent national commitments to the Paris Agreement on Climate Change and the stated intent by many countries to phase out the internal combustion engine—the Netherlands and Norway by 2025, India by 2030, Britain and France by 2040[11]. China has also announced that plans are underway to implement a ban on gas-powered vehicles. These global trends, along with the pressure on major automobile manufacturers to address this coming demand, are expected to usher in a shift to North American markets as well.

The overlapping of these disruptive transportation trends will likely amplify the impacts on how we move around the cities. How these trends will continue to change and ultimately interact with the built environment is a question that many experts are now trying to understand and predict.

3.0 PROJECTIONS

The next phase of the study was to explore how these changes may evolve over time, and how they might ultimately impact the way we live and move around cities. The existing body of research suggests a wide range of projections for how and when these disruptions to urban mobility will reach critical thresholds. What is clear is that the impacts on infrastructure and travel behavior will be profound. Projections for any of these disruptions tend to fall into either an evolutionary or revolutionary track, depending on the uptake of new technologies and the various political and regulatory obstacles which will impact these trends, as shown in Figure 4. The reality is that the adoption of these technologies is likely to continue to be incremental, with an extended and perhaps indefinite overlap between current practices and various transformational outcomes.

While it is impossible to know with certainty what form these transformations will take in the future, there is

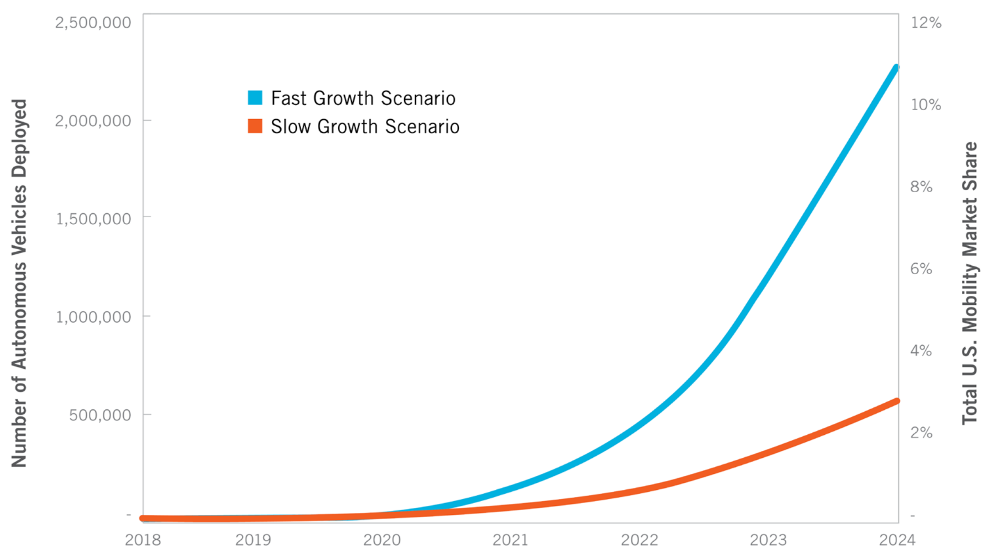

Figure 4: Estimated growth rate of automated mobility in top markets[12].

some emerging consensus around potential impacts of various scenarios that is useful in developing a strategy for planning.

3.1 Adoption Timeline

When it comes to self-driving vehicles, mobility companies expect to have fully automated vehicles operating as taxis on city streets as early as 2018, with self-driving vehicles hitting the private market within the next 3 years, and with the potential for a completely autonomous vehicle fleet sometime after 2050 (Figure 5). Of course, the rate of adoption is largely dependent on highly variable factors such as economic, legal and legislative obstacles, as well as general public acceptance. The adoption of these technologies will certainly be uneven across different types of cities and demographics[13].

Likewise, it is expected that vehicle sharing and ride hailing will continue to accelerate as a significant mode for urban mobility. Coupled with the emergence of self-driving technology, shared modes could account for the majority of all trips as soon as 2035[14]. Again, a myriad of external factors are likely to impact the extent to which shared mobility becomes a predominant mode of transport.

3.2 Cost of Travel

It is largely believed that coupling autonomous operation and vehicle sharing will reduce the cost per mile of travel to below the cost for personally operated vehicles or even public transportation today[14] (Figure 6). More affordable options for mobility could certainly benefit many people. However there are also risks, depending on the types of mobility that are prioritized.

Beyond the financial cost of mobility, another potential impact of autonomous vehicles is a decrease in the perceived “cost” of time for users. Throughout human history, people have generally allocated themselves a relatively consistent budget of time (roughly one hour) to travel each day— known as Marchetti’s Constant[15]. This has influenced the physical extent of cities over time as new technologies increase the distance that can be covered in a set period of time. Self-driving capabilities could not only increase travel speeds on freeways due to networking and more efficient use of roadways, but also challenge the assumption that time spent in transit is generally “unproductive” time for the driver. Because time previously spent behind the wheel could instead be used for work, entertainment or even sleep, the disincentive to make long trips on a regular basis would be greatly diminished. This could certainly result in an increase in the sprawl and auto-dependence of urban areas, encouraging people to live further away from the places they work and play.

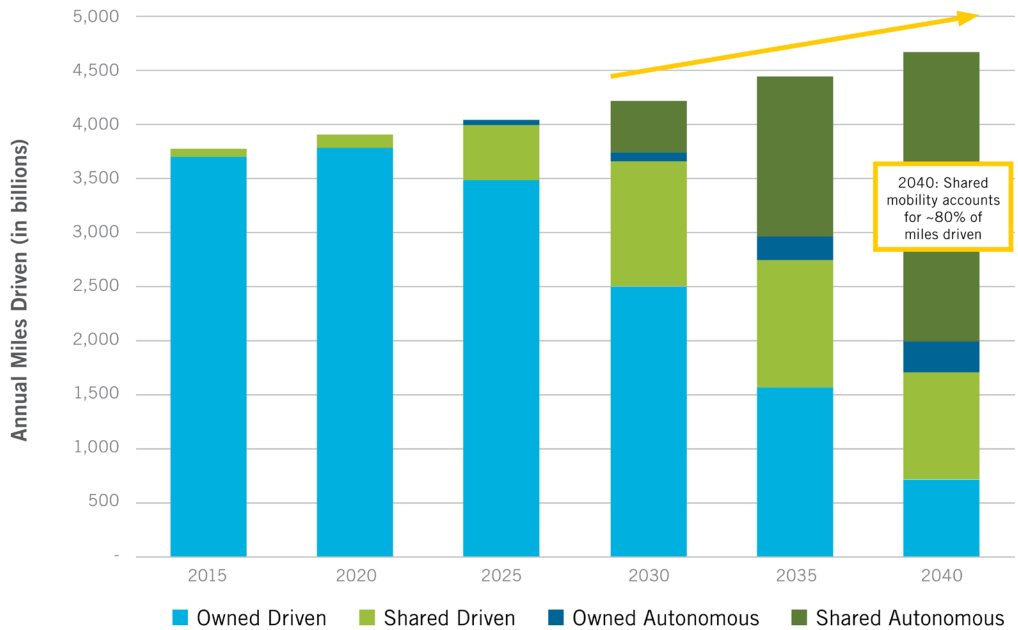

Figure 5: Projected automobile miles driven, by mode type[14].

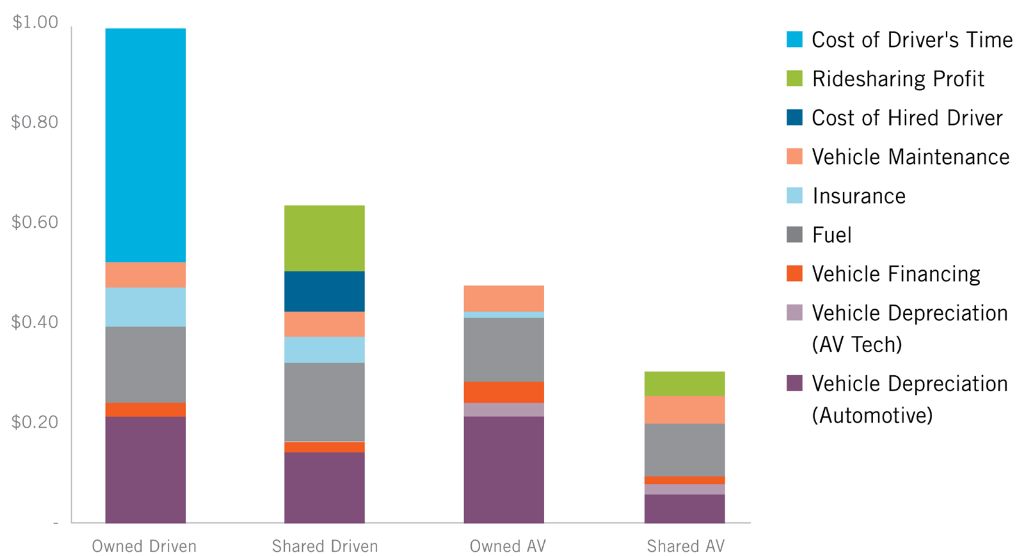

Figure 6: Projected cost per mile breakdown, by future state[14].

3.3 Vehicle Miles Traveled

It is well understood that decreasing costs, coupled with increased convenience, tends to induce additional demand for a service—this has been true across many economic studies, as well as in many previous innovations in transportation[16]. With decreases in the cost of mobility, as seen in Figure 6, and the replacement of trips formerly made by public transport, the resulting shift of more trips to low-occupancy vehicles would certainly result in an increase in congestion compared to the current condition. The trend towards an increase in vehicle miles traveled due to the availability of ride hailing services has already been well documented in cities such as New York and San Francisco, where up to half of new congestion and travel delays are attributed to TNCs[17]. This condition could be exacerbated further by the fact that many people who are not able to drive themselves today, including children and the elderly, would also have increased access to mobility with the introduction of self-driving vehicles.

Autonomous vehicles are largely expected to result in an increase in the number of vehicle miles traveled (VMT), between 5 percent and 60 percent compared with today, more than offsetting any potential roadway efficiencies that autonomous vehicles may offer[18].

3.4 Parking Requirements

A significant shift to shared vehicles could have profound impacts on the amount of space that is required for storing cars. While cars today spend the vast majority of every day sitting in a parking spot, simulations have shown that if shared vehicles were to replace privately owned for all trips, only 10 percent of the existing vehicle fleet would be required, with a corresponding reduction in the number of parking spaces needed in cities[19]. Given that automobile-related uses make up around a quarter of the total land area in North American cities, reducing the space needed for storing cars would free up vast amounts of land for other uses such as redevelopment and regeneration of green space.

The extent to which shared self-driving vehicles become the dominant form of personal mobility is still very much an open question. While shared modes have continued to trend upward, it is not yet clear to what degree self-driving technology may accelerate or reverse these trends; or to what extent most people would be willing to forego the convenience of private ownership.

Even if a large percentage of automobiles remain privately owned, parking demand is still likely to drop though less dramatically than in a fully shared scenario. Autonomous navigation and networked parking data would allow vehicles to utilize existing parking much more efficiently while still offering door-to-door service for passengers.

3.5 Public Safety

One of the primary benefits touted for self-driving vehicles is the expectation that they will result in much safer roadways, with the introduction of automated detection and crash avoidance technologies. The impacts on public safety could be significant. Today 1.2 million people around the world are killed annually as a result of automobile-related deaths[20]. The vast majority of these accidents are caused by human error that could theoretically be eliminated through automation. Studies suggest that between 80 percent and 90 percent of collisions and fatalities could be avoided with widespread adoption of autonomous vehicles[21]. The benefits could be seen most clearly among the most vulnerable street users, pedestrians and bicyclists. Making streets safer for walking and biking would result in the additional benefit of greater public health offered by active modes of transportation.

3.6 Greenhouse Gas Emissions

Studies suggest that the impact of future mobility on climate-altering greenhouse gas emissions could be reduced by half—or result in a 100 percent increase—depending on the factors that come to dominate urban transportation[18]. Such a broad range of possible outcomes speaks to the uncertainty and wide range of variables that are at play, including impacts on congestion, fuel efficiency, crash avoidance, and right-sizing vehicles.

Of these factors, the most significant impact on carbon emissions is the potential trend towards increased vehicle miles traveled. If coupled with a reliance on low-occupancy vehicles, whether shared or owned, this could dramatically increase the negative environmental impacts of the transportation sector without the implementation of significant changes to fuel sources and efficiency for vehicles. The extent to which electric vehicles and clean energy grids expand, as well as shifting more trips to more efficient multi-occupancy vehicles or active transportation, will be critical in mitigating greenhouse gas emissions and the broader environmental impacts of mobility in the future.

3.7 Privatization

One of the significant differences between current and past disruptions in mobility is a shift from public to private participation in the delivery of infrastructure. While public works projects invested in roadway and mass transit infrastructure have shaped much of the transportation landscape we see in cities today, it is information technologies, digital platforms, and start-up platforms that are playing an ever greater role in changing the way that we move today[22].

The integration and coordination of public and private sector roles highlights a unique shift that will be critical to the success of implementation. Planners will need to balance the role of the public in managing social and economic equity, with the cost and service efficiencies that are likely to emerge from the private sector.

Planning for changes to transportation will also be challenged by working across multiple jurisdictions and different levels of public sector governance to achieve coordinated solutions. Access to data across public and private sectors, and the ability to process and synthesize that information, will be critical to informing policy and shaping positive change.

4.0 LIVABLE CITY GOALS

How will these changes affect the built environment and impact the livability of our cities? In order to formulate principles that respond to these mobility trends, it was important to first define what we mean by a livable and sustainable city. For the purpose of this study, the following criteria have been used (Figure 7), which include broadly accepted goals and ambitions of cities today to inform the way we might evaluate values and decisions about the future of mobility and urban design[23, 24]:

Social Equity

- Provide access to high quality and affordable transportation for all.
- Ensure access to green space, schools, jobs and daily needs for all.
- Promote the exchange of goods, services and ideas.

Human Habitat

- Foster a vibrant public realm that supports a broad range of outdoor activities.
- Support compact and complete neighborhoods that minimize our impact on natural habitat while promoting community and active mobility.
- Design cities that are safe and accessible for people of all ages and abilities.

Environmental

- Prioritize transportation and infrastructure that has a low impact on the environment.
- Provide a functioning network of ecological networks and services.
- Support resilient environments that can adapt and respond to ecological changes.

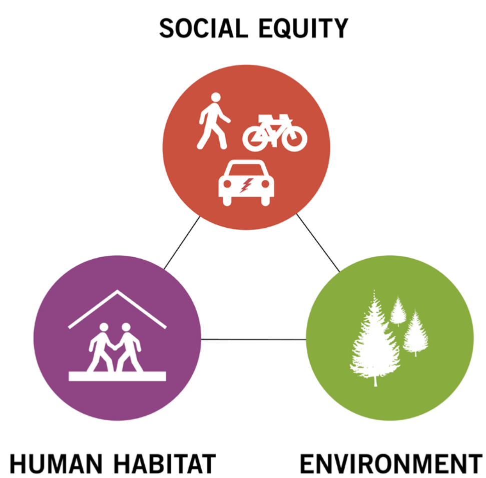

Figure 7: Livable city goals.

5.0 FUTURE MOBILITY PRINCIPLES

Future mobility will be highly disruptive to cities--for better or for worse. How we collectively design for that change will have a profound effect on capitalizing on opportunities and mitigating challenges. It will be critical for those interested in the future of cities to be clear about the type of city that is desirable and the values that will enable us to achieve that vision.

What should designers and planners advocate for given the broad range of possible outcomes, opportunities, and risks inherent in each of the trends that are shaping mobility? In order to answer this fundamental question, livable city goals were evaluated against future mobility trends to inform a values-based approach to guide decision-making, urban design, and policy. The following principles were identified as fundamental to achieving livable city goals (Figure 8):

1. **Make It Shared**
2. **Prioritize Multi-Occupancy Vehicles**
3. **Put Active Transportation First**
4. **Incentivize Low Carbon.**

Fundamental to all of these principles is a people-first approach—focusing on how we move people, not vehicles; creating social space instead of storing cars; giving people choice and promoting healthy lifestyles; and prioritizing modes that result in a cleaner and more sustainable environment.

By adopting these key principles, we believe that there is the potential to reduce the amount of space needed to operate and store vehicles, while increasing the capacity to move more people throughout our cities. The outcome will be healthier cities that realize a significant reduction in carbon emissions while creating meaningful space for people to move, interact, and connect.

Figure 8: Future mobility principles.

5.1 Make it Shared

Transportation policies should favor shared modes of all types over private ownership as a way to reduce the total number of vehicles in cities.

When vehicles are shared instead of privately owned, more space is made available for other uses. The average vehicle today sits unused 95 percent of the time, demanding an enormous amount of space in cities to store cars that sit idle[25]. Studies suggest that for every car share or rideshare vehicle on the road, as many as ten private vehicles are either unloaded or not purchased, (Figure 9)[26]. Given that road and parking infrastructure take up around 30 percent of the area of most cities, there is a great opportunity to convert much of this space to higher-and-better uses that support livability.

Car sharing--as well as non-vehicular shared modes such as bicycles, electric scooters, and personal mobility devices--can also effectively improve the range and attractiveness of high-capacity transit when co-located with rail and bus exchanges. This can further reduce demand for road and parking space in cities while transferring additional trips to less carbon-intensive modes of transportation.

5.2 Prioritize Multi-Occupancy Vehicles

Transportation policies should always prioritize high occupancy vehicles while supplementing public mass transportation through shared and self-driving modes.

Roadway capacity is a limited resource in every city, with the amount of space allocated per user having a direct impact on congestion and travel delays.

Even in a scenario where vehicles are shared, if ride-hailing or car share trips still tend to be made in single-occupancy vehicles, cities could face a significant increase in congestion and greenhouse gas emissions[19]. Sharing or self-driving mobility on its own does little to address this problem, especially if accompanied by an increase in vehicle miles traveled—which is why prioritizing multi-occupancy vehicles becomes even more important for future mobility. Public and active transportation modes will continue to be the most efficient, space-effective ways to utilize scarce road space now and into the future (Figure 10). Pairing shared vehicles with a quality, high-capacity public transport network has also been shown in simulations to have a significant decrease in the number of parking spots required and minimizing delays during peak travel times[19].

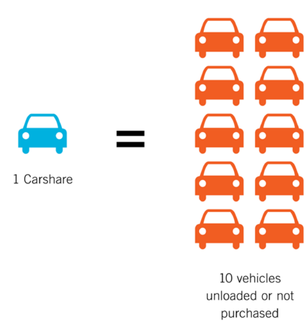

Figure 9: Displacement of private vehicles by carsharing[26].

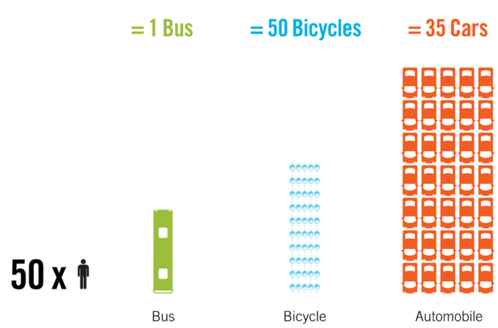

Figure 10: Road space requirements, by mode.

5.3 Put Active Transportation First

Decisions around future mobility should put active transportation first by considering a broad range of users and prioritizing pedestrians and bicyclists over private roadway users where different modes come in contact.

A key principle of a high-quality mobility network is to provide people choices in how they move around cities. Resiliency—not becoming overly reliant on a single mode or supplier of mobility—is a critical step and requires a consideration of both cost and distribution of access to multiple modes. Beyond furthering choice for residents, cities realize an enormous public health benefit and individual well-being by prioritizing active forms of transportation—walking, bicycling, etc. Well-documented benefits include reductions in obesity, cardiovascular disease, dementia, and overall mortality rates[27].

Users of active transport are also the most vulnerable users of the street, resulting in a disproportionately high percentage of fatalities and serious injuries on roadways. It is critical to implement the design of routes that are safe and inviting for all users (Figure 11). This means fundamentally limiting speeds and giving priority and maximum visibility to people over vehicles in the design of streets.

5.4 Incentivize Low Carbon

Policy must aggressively incentivize low carbon forms of mobility and improve the infrastructure needed to make them a convenient and affordable choice for most users.

The impacts of climate change are one of the most profound challenges that we will face over the next generation. Transportation continues to play a significant role in the amount of greenhouse gas emissions and air pollutants released into the atmosphere—accounting for between 20 and 30 percent of all emissions we produce (Figure 12)[28]. Carbon emissions are affected by fuel efficiency and energy source, which have been improving over time through improved fuel efficiency and the increase in electric vehicles. But emissions are also a product of the number of trips and miles traveled, which continue to increase globally and are expected to do so into the future as a result of changes in mobility.

Studies have shown that automation of a vehicle fleet could reduce greenhouse gas emissions by half, or nearly double them, depending on whether clean electric or carbon-based fuel comes to dominate[18]. Promoting more efficient multi-occupancy trips and no-carbon active mobility will also need to play a significant role in lowering greenhouse gas emissions from the transportation sector.

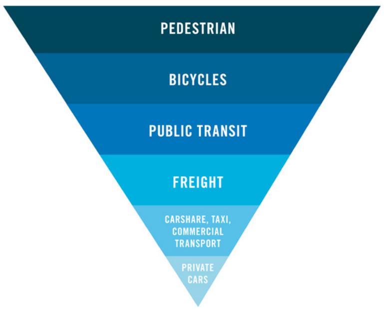

Figure 11: Prioritization of transportation modes.

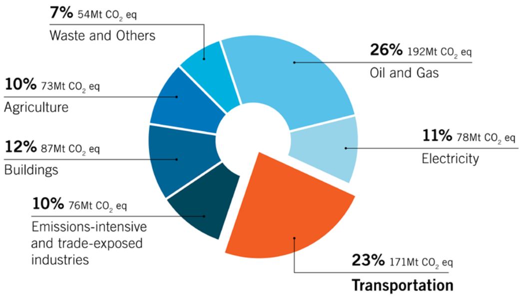

Figure 12: CO_2 emissions, by sector[28].

6.0 DESIGN OPPORTUNITIES

The next step of the research was to apply these future mobility principles to a range of urban design typologies. These design ideas and the typologies into which they are grouped in no way represent the full range of opportunities available to planners and designers considering the future of mobility. They are instead meant to be provocations that speak to key conditions found in many urban areas. They also represent ideas that could be tested immediately in existing urban areas and new developments. One of the key lessons from these examples is that anticipating changing mobility technologies should not be a matter of wait-and-see, but rather an active re-making already underway in cities around principles of livability, asking how changes in mobility can help to achieve the goals that have been set out. Ultimately, we believe that a proactive design approach is the most effective response to an open-ended design problem filled with uncertainty and a broad range of possible outcomes. If properly leveraged, current disruptions in mobility can be powerful tools towards enabling a much more livable city in the future. The opportunities identified here also come, uniformly, from a relatively simple premise underlying future mobility principles: put people first in the design of cities.

6.1 Off-Street Parking and Buildings

Parking for automobiles takes up an enormous percentage of land area in cities today—valuable space that could instead be leveraged for housing, open space or other uses that contribute to the livability of cities. With a shift to more shared modes of mobility, there is an opportunity to recapture much of the parking space in cities for more valuable purposes.

We can start by re-thinking off-street parking, first in temporary ways to support interim events such as pop-up food vendors and markets, and ultimately redeveloping underutilized surface parking for higher-and-better uses (Figure 13).

Parking that is built as part of new developments should be considered in the context of a future in which demand is much lower, requiring designers to consider a flexible approach that allows for different uses over time. All new parking should also incorporate electric charging capability in anticipation of near-term changes in power source for vehicles.

The most effective strategy may be limiting the amount of parking that we build today, and utilizing existing and

Figure 13: Reimagining parking.

future parking space in the most efficient way possible. In the same way that shared vehicles offer the benefit of reduced parking space requirements, sharing parking stalls among different users makes better use of a limited resource. Because parking demands vary over time and over the course of a day, networked and shared district parking can increase effective parking capacity without increasing supply. Reducing parking requirements for new developments also has the added benefit of reducing the construction costs and ultimately the cost of living if parking is decoupled from housing.

Finding ways to reduce, re-use and think creatively about how and where vehicles are stored means more space for the types of uses that are fundamental to livability: more and less-expensive housing, more public space, and more recreational space for people.

6.2 Curb and Sidewalk Zones

The threshold between the roadway and building frontages has evolved to become a hard line between the realm of the pedestrian and that of the automobile. Demand for the curb zone is likely to change as we move into the future of mobility—less space for parking, more demand for pick-up and drop-off zones, and greater opportunities for expanding spaces for people.

As we look forward to a future where parking space is less in demand for vehicles, but drop-off zones may become more important, we should think about designing curb space for ultimate flexibility, allowing for adaptation over time. An important first step includes the introduction of people-first spaces—parklets, cafe seating, green space, etc.—as a way of staking a claim for an improved public realm within valuable street space that may become redundant in the near future.

It will become increasingly important to put people first at crosswalks and other intersections between different modes. Particularly in a self-driving dominant future, there may be pressure to create separations between people and roadways to ensure the most efficient flow of networked vehicles is not disturbed by the unpredictable behavior of pedestrians and bicyclists (Figure 14). In a people-first model, pedestrians should be given priority at crossings and wherever different modes intersect.

Changes in mobility will transform the way in which we think about and utilize the threshold between street and sidewalk in cities. As these changes evolve, the emphasis must be on prioritizing the types of uses, such as space for people, bikes, and high-occupancy vehicles that will support livable city principles.

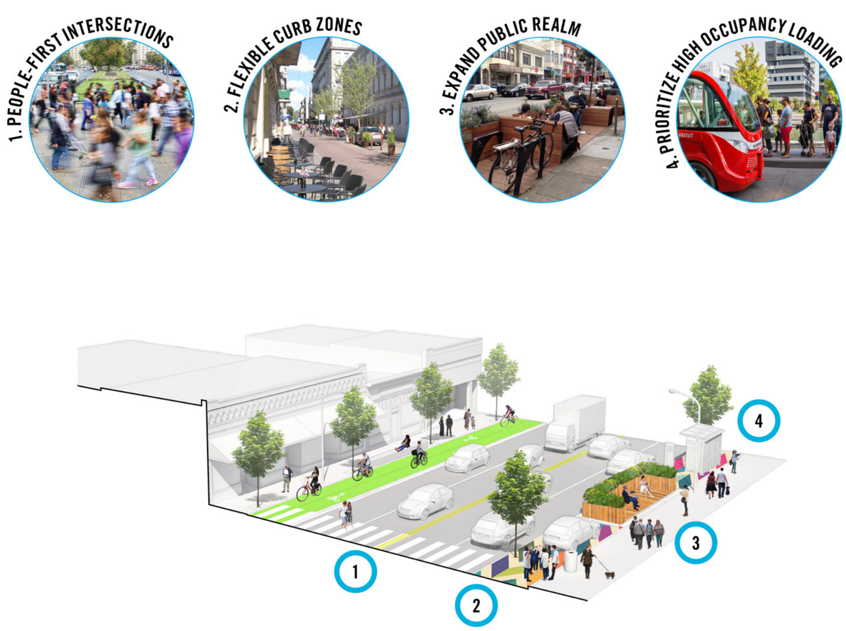

Figure 14: Reimagining curb and sidewalk zones.

6.3 Transit Exchanges

Public transit plays an essential role in freeing up roadway capacity, providing mobility choice for many travelers, and reducing the environmental impacts of transportation in large cities across North America. As we enter a future including automation and shared mobility, the role of high quality, high capacity mass transit will only become more important in delivering these benefits to urban areas.

Transit stations tend to be stand-alone structures today. As part of a new shared mobility ecosystem we need to start thinking of transit exchanges as hubs for the daily life of a city and region. This means designing transit stations that provide easy and intuitive links to a broad range of first and last mile transportation options for users— including bicycles, shared vehicle links, and the integration of places to work and live that make exchanges destinations in and of themselves (Figure 15).

It will also become increasingly important to share dynamic information about these various mobility options and integrate those options in a seamless way through the hub. As the transportation system becomes more "networked", transit hubs will play a central role in facilitating connections between public and private modes.

While automation and shared services offer the potential to revolutionize on-demand transit services and provide critical first and last connections within the transport network, high capacity corridors served by public transit will be essential to alleviate congestion from an overreliance on low occupancy on-demand services.
Without a vital high capacity transit system, it will be exceedingly difficult to deliver high functioning transportation within a livable city context in the future. Investing in and seamlessly integrating transportation nodes into communities is a crucial step in building a sustainable mobility future.

Figure 15: Reimagining transit exchanges.

6.4 Streets

City streets serve a broad range of functions and come in a wide variety of shapes and sizes. Today, the vast majority of street space is dedicated to the automobile—however the future of mobility will be about using public rights-of-way for a broad range of public uses, and focusing on increasing capacity through the promotion of high occupancy modes.

There is no one-size-fits-all approach when it comes to redesigning roadways for future mobility. There are different opportunities inherent in the many various street types, from high capacity transit corridors and arterials; to underutilized residential streets and laneways.

A key consideration in roadway design will be reallocating road space in support of the most efficient modes available—more space for high capacity automated transit and active transportation (Figure 16). In this way, existing rights-of-way will be able to carry as many or more people per hour as today, but using less overall space.

New York's Times Square is a great example of enacting people-first streets in an incremental way. The intersection was closed down to traffic, temporarily and relatively inexpensively at first, to test and monitor potential impacts. What planners and engineers found was that there was a huge demand for this type of public space in the city, resulting in improved foot traffic and retail activity as well as benefits for improving traffic congestion in the immediate neighborhood[29].

Another example that is currently being enacted in Barcelona is the "superblock", termed by Salvador Rueda. The concept involves focusing vehicular traffic on main arterial streets, freeing up streets within these larger blocks as people-first places that can accommodate vehicles under certain circumstances or at limited speeds[30].

The fundamental principle for future mobility street design is that the street should be considered first and foremost as a place for celebrating and moving people, not just vehicles.

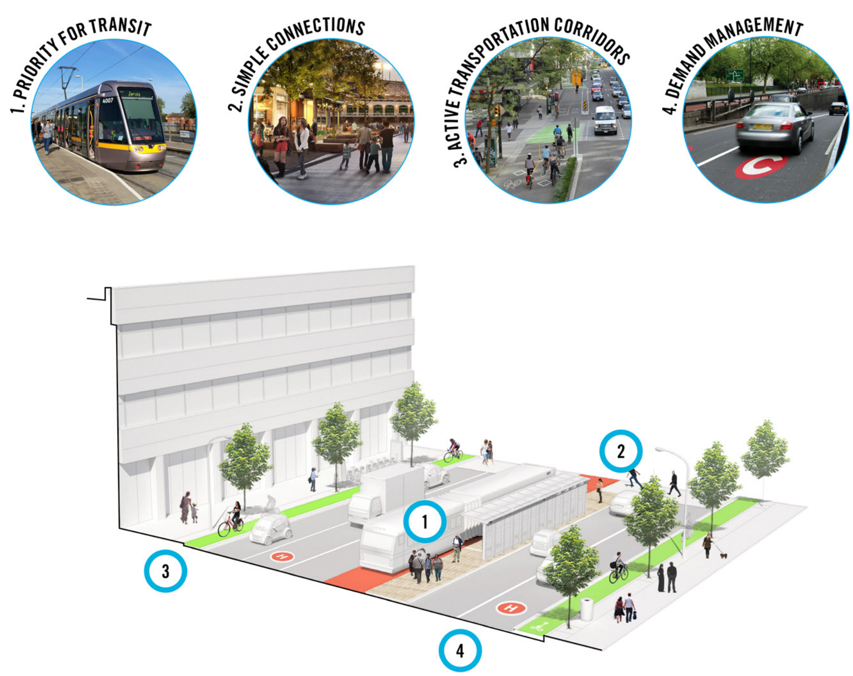

Figure 16: Reimagining transit corridors.

7.0 CONCLUSION

The intent of the study was to understand the potential impacts of future mobility technologies on the design of cities and define design principles that, when applied to design and planning decisions, would best support livable city goals.

A key conclusion of the research is that in order to achieve the best outcomes, we need to re-frame the approach to changes in urban mobility by focusing on people and the type of city we aspire to; then asking how future mobility technologies can help support this vision. Technological disruptions are highly unlikely to improve the equity, sustainability, and environmental quality of cities on their own. Rather, it will be critical that designers and planners understand and evaluate these trends while taking steps to proactively shape the future of mobility in a positive and purposeful way by implementing design changes that support livable city principles.

Changes in mobility already underway serve as a call to action for all of us—we each have an important role to play in shaping this future through design, planning, engineering, and broader behavioral shifts. It is important to remember that the future impact of these trends are not predetermined—rather mobility technologies are a tool which can be leveraged to achieve desirable outcomes. A more livable and sustainable future city is most likely to be achieved by focusing on a principled and people-first approach to re-shaping mobility.

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