Smart Cities and Transportation, and the Impact on Higher Education

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I. Overview

UPCEA is releasing a series of research papers examining four pillars of smart cities: Transportation, Infrastructure, Offices and Buildings, and Entertainment. This paper addresses the future of transportation in smart cities, presenting brief overviews of five of the leading technologies shaping transportation systems of the future: self-driving cars, smart public transportation, smart parking, ridesharing, and micro-mobility.

Transportation is one of the fastest emerging aspects of smart cities. Its development is possibly smart cities' most readily apparent and publicized feature. Uber and Lyft smartphone apps are ubiquitous, self-driving cars are constantly in the news, and e-bikes and e-scooters are penetrating most urban hubs. Every aspect of transportation seems to be changing.

Key findings of the smart city transportation report include:

- By 2040, driverless cars will make up to 75% of vehicles on the road.[8]
- Waiting for more and more safety upgrades for self-driving cars may be counterintuitive; more lives would be saved by deploying self-driving cars that are 10% safer than the average human driver rather than waiting years for them to be 75-90% safer.[11]
- Electric buses are the fastest growing vehicle in the electric vehicle (EV) segment; since 2013, their compound annual growth has been over 100%.[14]
- Electric buses are estimated to reach subsidy-free, purchase-price parity with diesel buses by the mid-2020s and by the 2030s at the latest.[15]
- Smart parking solutions would generate a 20-30% increase in a city's parking revenue.[22]
- By 2023, 16% of parking spaces will be "smart parking spaces."[25]

II. Introduction

Transportation is ripe for disruption. There are too many problems, particularly with respect to cars, that require comprehensive solutions. In the short term, we have seen apps like Waze emerge to help drivers avoid hazards such as potholes. In the long term, technology such as autonomous vehicles will help us avoid higher-order problems such as auto accident deaths.

Here is a snapshot of how problematic driving is in the United States:

- There are 6 million car accidents per year[1] and the number of auto accidents has been declining by approximately 1-2% from year to year.[2]

- Ninety people die from auto accidents each day, and each year 2 million people suffer permanent injuries.[3]

- Different studies from the 1970s to the present indicate that human error is either a probable cause behind or responsible for roughly 90% of auto accidents.[4]

- Just one self-driving car can positively influence the driving habits of at least 20 human-driven cars that are near it; this effect reduces "phantom" traffic jams, the kinds of road congestions that are caused by drivers' poor driving decisions.[5]

- Replacing all diesel buses, both transit and school buses, with clean electric buses would avoid an average of 7.3 million tons of greenhouse gas emissions per year.[6]

- Each American driver spends an average of 17 hours per year searching for parking which costs a total of $73 billion per year.[7]

Whether the transportation mode in question is automobiles, buses, or trucks, the overarching problem is the same. Transportation is a routine task and any routine task or function can become a target of automation. Cities can take the variability and risk out of driving and manage its resources better. A more stable, predictable system can save lives and improve the quality of life. Aside from these imperatives, vehicles will increasingly become greener and allow for new urban designs that will reshape how cities are navigated.

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[1] https://www.driverknowledge.com/car-accident-statistics/
[2] https://www.iii.org/fact-statistic/facts-statistics-highway-safety
[3] https://www.driverknowledge.com/car-accident-statistics/
[4] http://cyberlaw.stanford.edu/blog/2013/12/human-error-cause-vehicle-crashes
[5] https://www.usatoday.com/story/money/2018/07/03/self-driving-reduces-traffic-jams-study-says/741985002/
[6] https://environmentamerica.org/reports/ame/paying-electric-buses
[7] Ibid.

III. Self-Driving Cars

Urban designs will shift away from a focus on roadways and become more aesthetically pleasing. City governments will need to find new sources of revenue in order to fund the city of the future.

Upgraded urban designs and better pedestrian experiences

The potential impact of autonomous, self-driving cars is enormous. The Institute of Electrical and Electronic Engineering estimates that driverless cars will make up to 75% of vehicles on the road by 2040. Even smaller details of urban life will be affected. For example, with less and less human drivers, parking tickets and towing services might one day become obsolete.[8]

In terms of higher order changes, a common critique of current cities is that they were built and developed to accommodate cars. Now, many people believe that autonomous, self-driving cars will make cities more pedestrian-centric by transferring much needed real estate to other city services. The World Economic Forum and the Boston Consulting Group predict that in Boston, self-driving cars would need half of the city's current parking spaces to operate on parity with traditional automobiles.[9] This means fewer parking spots on the street and fewer parking garages. Public transit as well as bike and scooter lanes will be wider and more protected, and parking garages can be converted into more aesthetically pleasing, useful buildings. Alternatively, the extra space could be used for additional parks or more "green space" along city roads.[10]

When will self-driving cars navigate city roads?

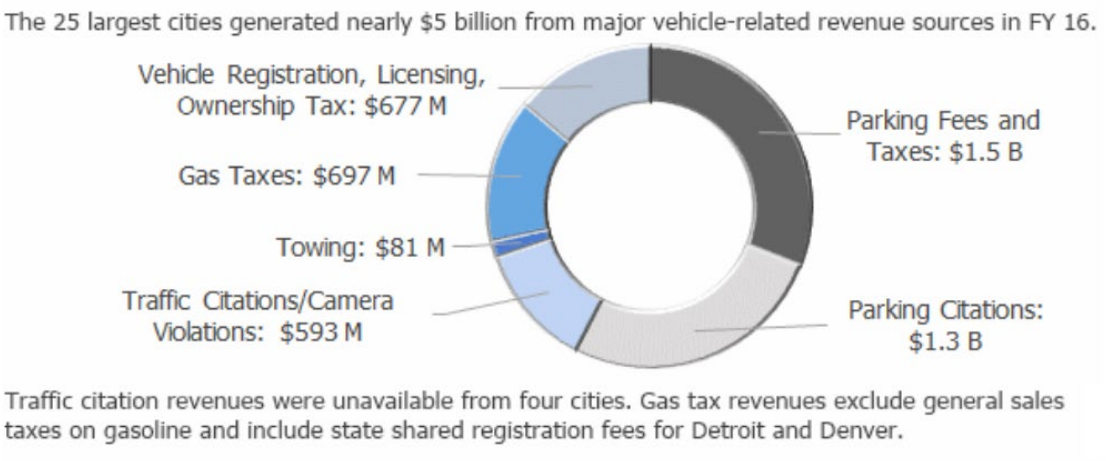
The future of self-driving cars is still questionable. There are philosophical questions that underpin the technological issues of smart city innovations. For instance, how much safer do self-driving cars have to be than human-driven cars? Researchers from the RAND corporation found that even a marginal safety advantage would ultimately save more lives. Specifically, deploying self-driving cars that are 10% safer than the average human driver will save more lives than waiting until driverless cars are 75% or 90% safer.[11]

City government questions must be answered as well. The nation's 25 largest cities gain approximately $5 billion in auto-related revenues. Lois Scott, the former CFO of Chicago, predicts that cities will lose an average of 10-15% of their operating revenues due to self-driving vehicles.[12] City budgets will suffer since self-driving cars will likely incur fewer traffic-related fines. New forms of taxation may also be required. Cities may be hesitant to deploy self-driving cars until new revenue sources can be identified.

[8] https://www.wired.com/insights/2013/08/top-5-market-trends-driverless-cars-will-rev-up-in-the-future/
[9] https://www.washingtonpost.com/transportation/2019/07/20/city-planners-eye-self-driving-vehicles-correct-mistakes-th-century-auto/
[10] https://www.wired.com/story/self-driving-cars-cities/
[11] https://www.vox.com/recode/2019/5/17/18564501/self-driving-car-morals-safety-tesla-waymo
[12] https://www.governing.com/topics/finance/gov-cities-traffic-parking-revenue-driverless-cars.html

Figure 1 breaks down the $5 billion in revenue that the United States' 25 largest cities generate from vehicles. The $677 million from vehicle registration, licensing, and ownership may be relatively safe. However, the other five areas of automobile revenue, totaling about $4 billion, are in jeopardy of being disrupted by self-driving cars.[13]

Figure 1: Largest 25 U.S. cities' Vehicle Related Revenue Sources Breakdown



Source: Governing.com

Figure 2 shows examples of self-driving car fleets that are being tested. Technology companies and the Big 3 automotive companies alike are racing towards mass production of self-driving cars. On the left, Waymo (Google)'s self-driving fleet is being tested in Arizona. On the right, the self-driving car from Ford and Argo AI's partnership is being testing in Pittsburgh, PA.

Figure 2

Source: Reuters

Source: Pittsburgh Post-Gazette

[13] https://www.governing.com/topics/finance/gov-cities-traffic-parking-revenue-driverless-cars.html

IV. Smart Public Transportation

Cities continue to search for cleaner and more space-efficient ways to transport citizens. Electric buses and self-driving shuttles could be the answer to both those challenges.

Electric Buses

Electric buses are the fastest growing vehicles in the electric vehicle (EV) segment. Their compound annual growth rate since 2013 has been over 100% compared to 60% for electric passenger cars.[14] Electric buses are estimated to reach subsidy-free, purchase-price parity with diesel buses by the mid-2020s and by the 2030s at the latest.[15]

Indianapolis has one of the best examples of what electric city bus systems could look like. Its new Red Line electric bus service represents steps towards cleaner, more efficient cities. These buses have battery lives for a range of 275 miles. The city created two, red-painted "buses only" lanes that run 13.1 miles, connecting the greater city area to downtown areas. The electric buses are 60 feet long and arrive every 10 minutes during the week and every 15-20 minutes on weekends. There are apps that allow citizens to replenish fare cards as well as plan and schedule their trips. Free public Wi-Fi is available at every station and on every Red Line bus.[16]

Self-Driving Shuttles

This form of public transit is still behind the electric bus's rollout due in part to technology development. It is also due to the public's reluctance to fully trust autonomous vehicles as a result of the four self-driving car fatalities in the U.S.[17]

In August, New York City launched its first autonomous shuttle in the private streets of Brooklyn Yards, a historic manufacturing area turned tech hub. Citizens can now share these six-person shuttles with two engineers through Brooklyn Yards, a controlled environment. The engineers are able to demonstrate to passengers that the shuttle is able to swerve or stop to avoid pedestrians, depending on speed and distance. Soon, the company behind these shuttles, Optimus Ride, intends to take the shuttles to public roads.[18]

This shuttle is not the first of its kind, however. Numerous universities and cities have been experimenting with their own public, self-driving shuttles. One is Columbus, Ohio which unveiled its self-driving shuttle in December 2018.[19] It also won $50 million from the U.S. Department of Transportation's first-ever Smart City Challenge for its autonomous transit fleet.[20]

[14] https://www.mckinsey.com/industries/automotive-and-assembly/our-insights/fast-transit-why-urban-e-buses-lead-electric-vehicle-growth
[15] https://www.sierraclub.org/articles/2019/02/for-us-transit-agencies-future-for-buses-electric
[16] https://www.indystar.com/story/news/local/transportation/2019/08/29/red-line-indygo-how-use-bus-rapid-transit-indianapolis/2060619001/
[17] https://www.technologyreview.com/f/614090/new-york-citys-first-self-driving-shuttle-service-launches-today/
[18] https://futurism.com/nyc-self-driving-shuttle
[19] https://smart.columbus.gov/projects/self-driving-shuttles
[20] https://www.columbuspartnership.com/community-impact/smart-cities/

The first image in Figure 3 displays an Indianapolis Red Line bus route, one of the “electric bus only” red lanes that the city created, as well as a Wi-Fi-enabled bus station. The second picture is of an autonomous, six-seater shuttle in Brooklyn Yards.

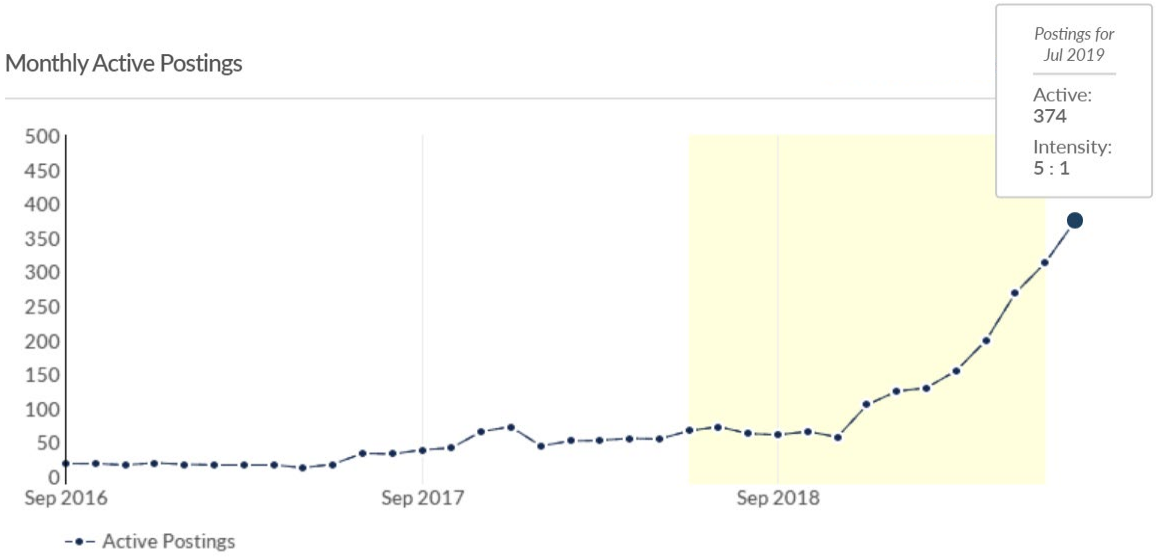
Figure 3: Red Line Electric Bus in Downtown Indianapolis & Self-Driving Shuttle in New York City

Source: The Indianapolis Star

Source: MIT Technology Review

Figure 4 shows the rise in job postings in the United States that contain at least one of the following phrases: "electric bus engineering," "self-driving shuttles,” "electric buses," "self-driving shuttles," "autonomous shuttle," "autonomous bus, or “self-driving shuttle engineering." In September 2016, there were 19 active job postings for these occupations. In July 2019, this figure had risen to 374 active postings.

Figure 4: Monthly Active Job Postings for Electric Bus and Autonomous Shuttle -Related Jobs



Source: Economic Modeling Specialists International – 2019.3 Dataset

V. Smart Parking

Inefficient parking has been an issue that cities have not been able to comprehensively solve. Allowing parking spaces to "talk" to smartphones and self-driving vehicles may be the answer.

What is smart parking?

Smart parking describes the technology behind city parking spaces being connected to the Internet which may become a service in the future that is easily accessed by citizens. Smart parking solutions will not structurally change the way citizens will use parking spaces, but they will change how they interact with them. Smart parking-enabled parking spaces use sensing technologies such as cameras, counting equipment at the gates of parking garages, and sensors embedded into the pavement of individual parking spaces.[21] On our smartphones, we already use apps such as Google Maps or Waze to receive live, real-time information on the distance of our trips, road closings, and traffic congestion. These location services make our travel decisions more informed. Smart parking apps will be the next addition to our smart location services.

Why is smart parking important?

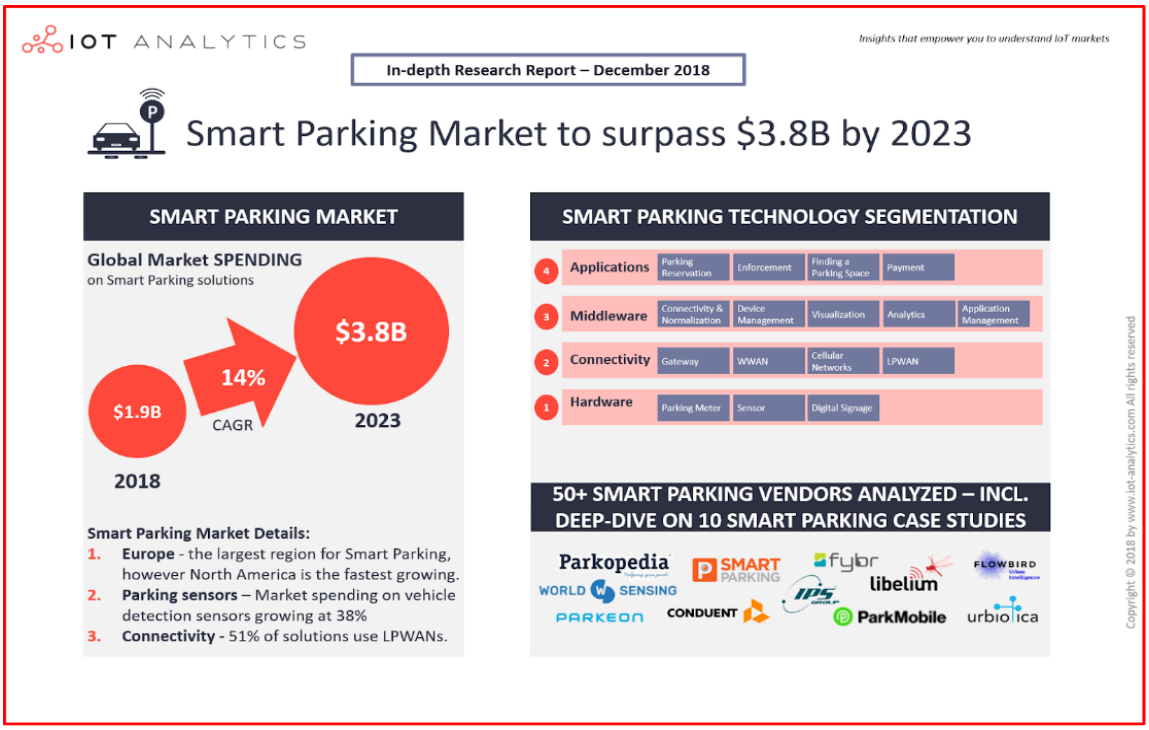
It has been said that the road to smart cities will be paved with smart parking. There is a financial logic behind this sentiment. On average, parking is the second or third highest revenue source for a city. Companies such as Streetline estimate that smart parking solutions would create a 20-30% increase in a city's parking revenue. Therefore, investments in smart parking may be the best starting point for smart cities, improving city budgets and enhancing city services.[22]

These are services cities sorely need. Congested streets pose challenges to cities all over the globe. Recently, New York City became the first city in the U.S. to unveil a congestion pricing plan that will come into effect in 2021.[23] The reasoning behind the policies is that, on average, 30% of all traffic in urban areas is caused by drivers and motorists searching for parking spaces.[24] Armed with better smart parking information, cities will have reduced traffic congestion. Driver experience will be improved, space usage will be optimized, and cities will have less pollution. Smart parking will also work in tandem with self-driving cars. Both technologies will be able to "talk" to one another, allowing autonomous vehicles to automatically drive to an open parking space. Currently, 11% of global public parking spaces are now "smart." By 2023, that figure is expected to reach 16%.[25]

[21] https://www.realcomm.com/advisory/620/1/smart-parking-what-is-it-how-can-your-facility-benefit
[22] https://newcities.org/smart-parking-makes-way-smart-cities/
[23] https://www.pri.org/stories/2019-05-30/new-york-city-gets-nations-first-congestion-pricing-plan
[24] https://www.softwebsolutions.com/resources/smart-parking-iot-solution.html
[25] https://iot-analytics.com/smart-parking-market-report-2019-2023/

Figure 5 details the expected $2 billion increase in smart parking spending, the four different segments of smart parking technology, and the logos of ten firms entering the market.

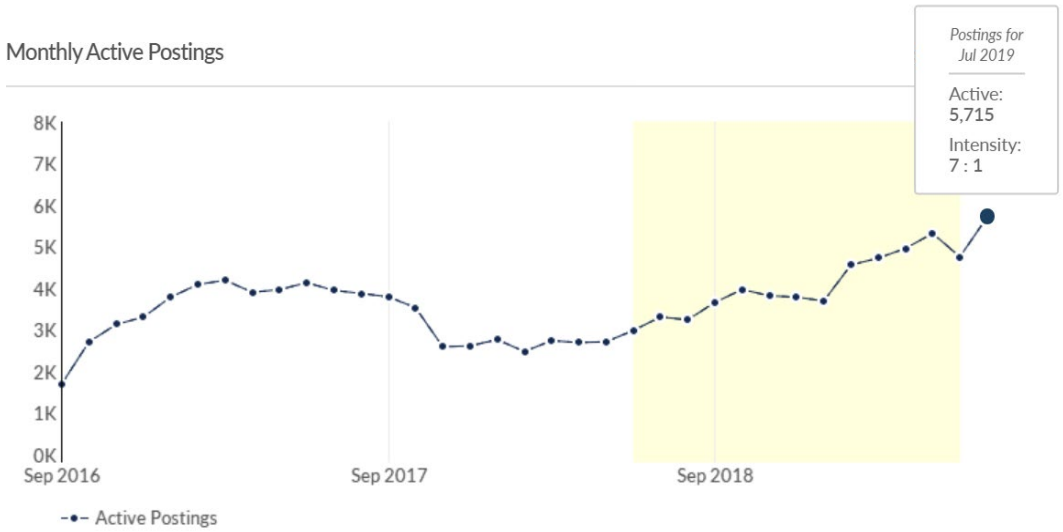
Figure 5: Overview of Smart Parking Market, Technology Segments, and Vendors



Source: IoT Analytics – December 2018 – Smart Parking Market Report 2019-2023

Figure 6 shows the rise in job postings in the United States that contain the phrase "smart parking." In September 2016, there were 1,706 active job postings for smart parking jobs. That figure grew to 5,715 active job postings by July 2019.

Figure 6: Monthly Active Job Postings for Smart Parking-Related Jobs



Source: Economic Modeling Specialists International – 2019.3 Dataset

VI. Ridesharing

Ridesharing which is already on the market will continue to shape transportation and mobility trends. Ridesharing firms are in the process of creating self-driving cars. They are also making a sizeable difference in other ways such as creating synergy with public transit to create more integrated urban mobility and collecting the data cities need to become smart.

Integration with other forms of transportation

City governments and agencies have recently partnered with major U.S. ridesharing companies. Since 2016 and 2017, Atlanta's MARTA on the Go, the city's transit app, links directly to the Uber and Lyft apps. Dallas also has a similar arrangement with both technology firms.[26]

These integrations have the potential to tackle a variety of urban mobility issues. One of these is the "last mile" challenge of urban mobility when one's destination is too far to comfortably walk from a public transit node. Another integration is helping people who live in areas without reliable public transits. Centennial, Colorado and Altamonte Springs, Florida have been subsidizing their residents' and visitors' ridesharing rides to the nearest train station.[27] Ultimately, these trends indicate that cities may be headed towards a more fully integrated city transportation experience where one service begins where the other ends.

Making smart cities smart

Simply put, for smart cities to be smart, they need the collection of data, particularly transportation data. One way this is beginning to happen is through a startup called Firefly. This tech firm converts ridesharing vehicles into a mobile data network, installing a smart screen sensor on top of drivers' cars. Once the sensors are installed, drivers are paid for the data they collect on each ride, and cities get access to much-needed data.[28] The screens also double as electronic ads.[29]

Another way ridesharing vehicles can furnish cities with data is through direct partnerships. Consider the three-year partnership Uber formed with Cincinnati's Mobility Lab in 2018.[30] After a year of data collection, Uber issued several recommendations to reduce Cincinnati's congestion. Some examples included changes to valet permit policies, curb space designation changes, and new traffic control measures for the busiest streets.[31]

[26] https://datasmart.ash.harvard.edu/news/article/how-cities-are-integrating-rideshare-and-public-transportation-978
[27] http://theconversation.com/can-public-transit-and-ride-share-companies-get-along-64269
[28] https://innotechtoday.com/smart-cities-traffic-data/
[29] https://venturebeat.com/2019/05/30/firefly-raises-30-million-to-mount-digital-display-ads-on-ride-hailing-cars/
[30] https://geomarketing.com/uber-expands-smart-city-initiatives-launching-a-mobility-lab-in-cincinnati
[31] http://www.fehrandpeers.com/wp-content/uploads/2019/01/CincinnatiCurbStudy_2019-01.pdf

VII. Micro-mobility

The reshaping of our cities will also be impacted by scooters, bicycles, skateboards and other innovative modes of transportation. This category is often called micro-mobility and includes e-scooters and e-bikes, as well as docked bikes. In some societies, modes of micro-mobility transportation have been well-received and a common form of transportation. Many cities in Europe and Asia are built around micro-mobility transportation or have recently adopted them in the form of bike highways and lanes solely for micro-mobile transportation. The United States continues to struggle and debate the integration of micro-mobile modes of transportation, despite generational interest. Micromobility continues to grow. According to the National Association of City Transportation Officials, consumers took 84 million trips on shared micro-mobility vehicles in the United States in 2018, twice the number of trips taken in 2017.[32]

The benefits of micro-mobility in a smart city include increased health benefits, a less reliability on fossil fuels, less congestion of roadways and less infrastructure needed to park a micro-mobile form of transportation. For a smart city, greater efficiencies are often experienced due in part to travel being shorter, compared to conventional transportation. Worldwide, 60% of car trips are less than 8 kilometers or 5 miles.[33]

Adoption of micromobility solutions are expected to increase in the U.S. generationally, as younger adults have less disposable income and have fueled the sharing economies and companies like Lyft and Uber. These consumers are also more likely to ride share not only cars, but bikes and scooters as well. Some will own their bikes, scooters or skateboards, electric or human powered.

For smart cities, micromobility solutions may be less costly, more environmentally sound, faster than driving or riding in a car or via public transportation, and easier to park or store. There are negative factors to consider, including weather and safety-related concerns and product abandonment. The Center for Disease Control (CDC) released a report on May 2, 2019, detailing statistics related to e-scooters and injuries. The report found that injuries occur roughly 14.3 times per every 100,000 trips. The CDC found that head injuries were the most common type of injury (45%), followed by upper extremity fractures (27%) and lower extremity fractures (12%). The report suggested that many of the injuries could have been prevented if riders were wearing helmets and were more careful around cars.[34] Despite alarming scooter accident rates, overall, increased adoption of micromobility solutions would most likely improve health, as pollution may decrease and health may improve as a result of greater exercise.

[32] https://nacto.org/shared-micromobility-2018/

[33] Heineke, K., Kloss, B., Scurtu, D., Weig, F. "Micromibility's 15,000-mile checkup," McKinsey and Company, January 2019.

[34] https://www.cnbc.com/2019/05/01/cdc-study-says-e-scooter-injuries-are-largely-preventable-with-helmets.html

VIII. Impact on Higher Education

The technology, engineering and automotive industries will be the most directly impacted by smart cities' redesigned transportation systems. There are many other fields that will change as well, including media and entertainment, health and wellness, supply chain logistics, insurance, litigation, cybersecurity, public policy development and many more.

New technologies will emerge that require upskilling, such as constantly securing autonomous vehicles from hacking or improving 5G networks and future network technologies for signal transmission and management of an autonomous vehicle fleet. GPS and other tracking technologies will require an already skilled workforce to become more skilled. Analytics will also be the foundation for many AI-dependent means of transportation. Sensing technologies such as sonar, radar and other tools will continue to improve and change. It is very likely that new technologies will increase the number of engineering, science and information technology degrees and training opportunities for higher education.

Infrastructures in our smart cities will also change, as parking will change depending on vehicle type, micromobile or not. In the future city, many workers will also work remotely and be less dependent on physical presence. These trends are likely to power new developments in satellite, 5G and other communications technologies. As infrastructures change, open spaces and new development within our cities will change, thus potentially fueling community and economic development, architectural and design, energy and engineering professions. New degrees and training opportunities will develop around these new occupational growth areas.

Industries indirectly related to transportation, such as healthcare, environment, government, policy and law are also likely to be impacted by transportation shifts as a result of smart city evolution. The health of citizens in smart cities is likely to improve due to lower pollution and increased exercise. In any changing economy, new laws and policies will emerge while old ones will be challenged, thus impacting our legal and governmental systems. Local, regional and national governments will ponder philosophical questions and need to execute effective policies around transportation and infrastructure to better manage cities of the future. Higher education has an opportunity to develop new curricula around these agendas.

The ways that higher education institutions will be impacted are sizeable. Some higher education programs will expand, while others will shrink, be upgraded, or even eliminated. Self-driving cars are tied to a future reduction in litigation, which could ultimately reduce demand for law degrees in the long run. However, new litigation could emerge from safety incidents from micromobility means of transportation.

Degrees will need to be approved more quickly and be more adaptable if degrees are to survive and be the mainstay for many technologies that will impact transportation. Content will need to be modular without delays due to long academic approval processes. Alternative credentialing in the form of certificates will provide new avenues to enhance existing educational credentials to avoid career obsolescence, as well as help others change careers.

For longer travel and with the assistance of a fully automated self-driving vehicle, the passenger will have more free time, opening the door for additional education, more entertainment or improving health or well-being through additional sleep, exercise or nutrition. Institutions of higher education may be able to leverage this free time for learning.