The University of Iowa | Office of Outreach and Engagement

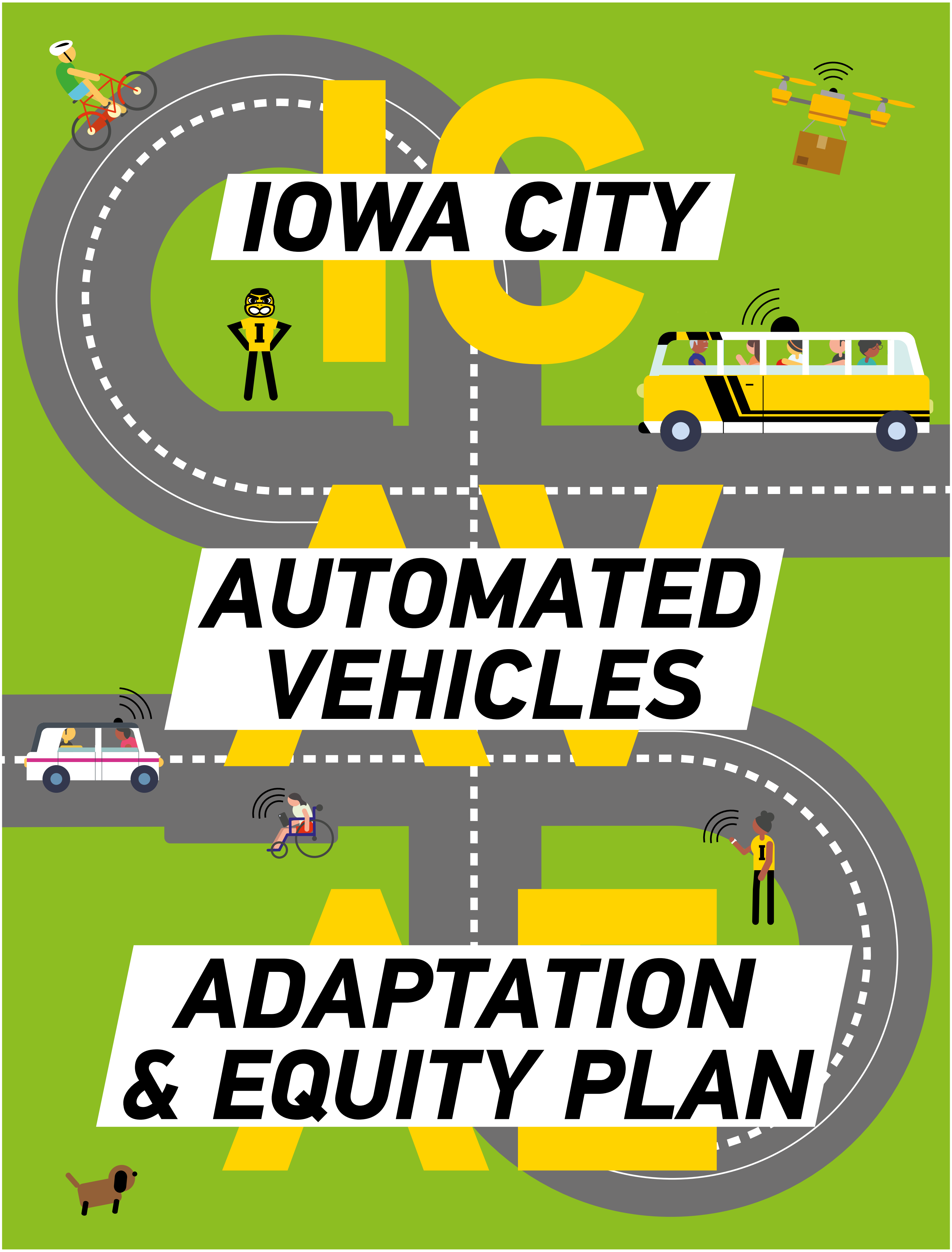
FINAL DELIVERABLE

Title	Iowa City Automated Vehicles Adaptation & Equity Plan
Completed By	Chanel Jelovchan, Bogdan Kapatsila, Hossain Mohiuddin, Jeremy Williams
Date Completed	May 2019
UI Department	School of Urban & Regional Planning
Course Name	Field Problems in Planning | URP:6209:0001
Instructor	Jerry Anthony, Steve Spears
Community Partners	City of Iowa City, National Advanced Driving Simulator

This project was supported by the Provost's Office of Outreach and Engagement at the University of Iowa. The Office of Outreach and Engagement partners with rural and urban communities across the state to develop projects that university students and faculty complete through research and coursework. Through supporting these projects, the Office of Outreach and Engagement pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

Provost's Office of Outreach and Engagement
The University of Iowa
111 Jessup Hall
Iowa City, IA, 52241
Phone: 319.335.0684
Email: outreach-engagement@uiowa.edu
Website: http://outreach.uiowa.edu/

IOWA CITY AUTOMATED VEHICLES ADAPTATION & EQUITY PLAN



This project was supported by the Provost's Office of Outreach and Engagement at the University of Iowa. The Office of Outreach and Engagement partners with rural and urban communities across the state to develop projects that university students and faculty complete through research and coursework. Through supporting these projects, the Office of Outreach and Engagement pursues a dual mission of enhancing quality of life in Iowa while transforming teaching and learning at the University of Iowa.

Research conducted by faculty, staff, and students of The University of Iowa exists in the public domain. When referencing, implementing, or otherwise making use of the contents in this report, the following citation style is recommended:

Chanel Jelovchan, Bogdan Kapatsila, Hossain Mohiuddin, Jeremy Williams, led by Dr. Jerry Anthony, Dr. Steven Spears. 2019. Iowa City Automated Vehicles Adaptation & Equity plan. Research report produced through the Office of Outreach and Engagement at the University of Iowa.

This publication may be available in alternative formats upon request.

Provost's Office of Outreach and Engagement
The University of Iowa
111 Jessup Hall
Iowa City, IA, 52241
Phone: 319.335.0684
Email: outreach-engagement@uiowa.edu
Website: http://outreach.uiowa.edu/

CITY OF IOWA CITY
UNESCO CITY OF LITERATURE

THE NATIONAL ADVANCED DRIVING SIMULATOR

THE UNIVERSITY OF IOWA | Office of Outreach and Engagement

School of Urban & Regional Planning

IOWA CITY AUTOMATED VEHICLES ADAPTATION & EQUITY PLAN

MAY 2019 REPORT

Completed by:

Chanel Jelovchan
Bogdan Kapatsila
Hossain Mohiuddin
Jeremy Williams

Faculty Advisers:

Dr. Jerry Anthony
Dr. Steven Spears

UI Department:

School of Urban & Regional Planning

Course:

Field Problems in Planning

Community Partners:

City of Iowa City
The National Advanced Driving Simulator

ACKNOWLEDGEMENTS

We would like to thank the following people for their help throughout the planning process. Their insight and expertise greatly assisted the development of this plan.

Project Partners:

Anna Dizack
Proposal Development & Communications, the National Advanced Driving Simulator, the University of Iowa

Darian L. Nagle-Gamm, AICP
City of Iowa City Director of Transportation Services

University Partners:

The National Advanced Driving Simulator

The Office of Outreach and Engagement

School of Urban and Regional Planning

Project Advisers:

Dr. Jerry Anthony
Associate Professor, the University of Iowa

Dr. John Fuller
Professor, the University of Iowa

Travis Kraus
Director of Economic Development & Sustainability, the Office Outreach and Engagement, the University of Iowa

Dr. Steven Spears
Assistant Professor, the University of Iowa

TABLE OF CONTENTS

FIGURES

TABLES

GLOSSARY

ACS - American Community Survey
ADS - Advanced Driving System
AI - Artificial Intelligence
APTA - American Public Transportation Association
AV - Automated Vehicles
BLS - Bureau of Labor Statistics
CBD - Central Business District
CIP - Capital Improvement Plan
FHWA - Federal Highway Administration
FTA - Federal Transit Authority
GHG - Greenhouse Gases
HOV - High Occupancy Vehicle
MPO - Metropolitan Planning Organization
MSA - Metropolitan Statistical Area
NACTO - National Association of City Transportation Officials
NHTSA - National Highway and Traffic Safety Association
NMVCCS - National Motor Vehicle Crash Causation Survey
PUDO - Pick-Up and Drop-Off
RPPP - Residential Parking Permit Program
SAV - Shared Automated Vehicle
SNAP - Supplemental Nutrition Assistance Program
TNC - Transportation Network Company
U.S. DOT - United States Department of Transportation

EXECUTIVE SUMMARY

The Iowa City Automated Vehicles Adaptation and Equity Plan is designed as a policy guidebook for City leaders to consider and apply in future planning activities. It addresses the current mobility challenges facing residents while setting the stage for a seamless integration of automated vehicles (AVs) in the future. Based on literature review, data analysis, and public engagement in the form of interviews with key stakeholders and a public open house, this document contains a series of policy interventions that leverage Iowa City's key transportation assets to preserve its walkable, pedestrian-oriented community in light of recent developments in automated vehicle technologies. Furthermore, the Iowa City Automated Vehicle Adaptation and Equity Plan identifies the current aspects of the local transportation system that can be improved upon to assist the City in realizing the vision and goals set forth in the guiding planning documents, such as the IC2030 Comprehensive Plan and the Climate Action Plan, while mitigating the potential adverse impacts associated with AVs.

Beginning with an overview of automated vehicles and the current status of this technology, the plan then presents the prospective benefits and challenges related to AVs and the general framework for Iowa City to follow in anticipating this technology. Next is an overview of the methodology that guided the plan's creation and a discussion of recent transportation planning activities conducted by the City. The plan then describes the challenges and needs of the local transportation system that were articulated by key stakeholders in interviews held with the planning team. Based on literature review and the input obtained in the stakeholder interview sessions, three main focus areas were delineated - shared mobility, Iowa City transit, and parking and land use.

The current landscape of the three focus areas within the context of Iowa City are described to illustrate how they relate to AVs as well as how they can be leveraged to address the existing mobility challenges faced by residents at the downtown, city, and regional level while incorporating a timeline for implementing the associated policy interventions presented in the plan. Below is a summary of the policy interventions for each focus area:

Shared Mobility

- Implement a Pick-Up and Drop-Off (PUDO) management plan in downtown Iowa City for regulating public right of way in the context of transportation network companies (TNCs), paratransit operations, commercial operations in the short-term and pave the way for the management of automated vehicles operation in the future.

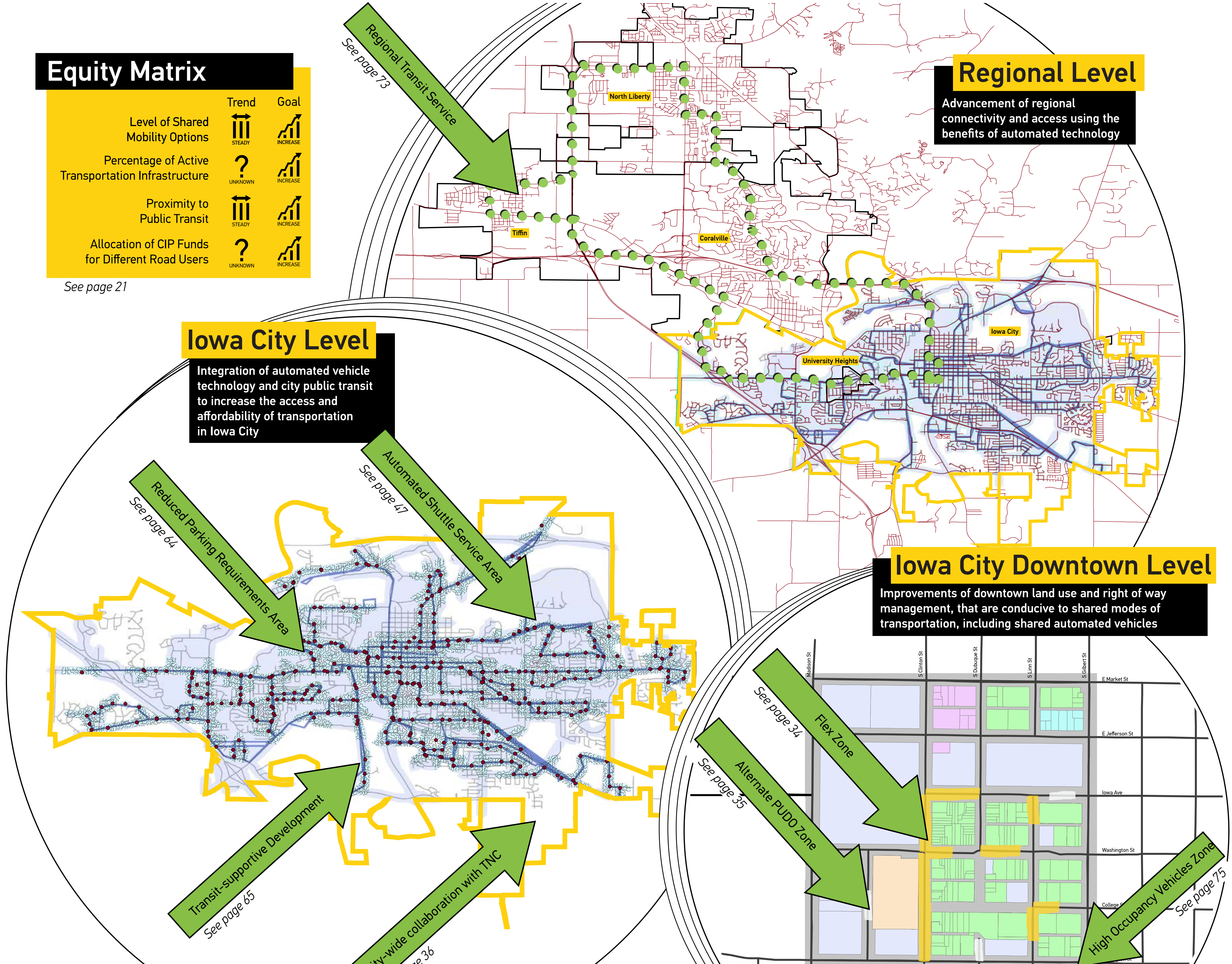


Figure 1: Plan summary (Source: Authors)

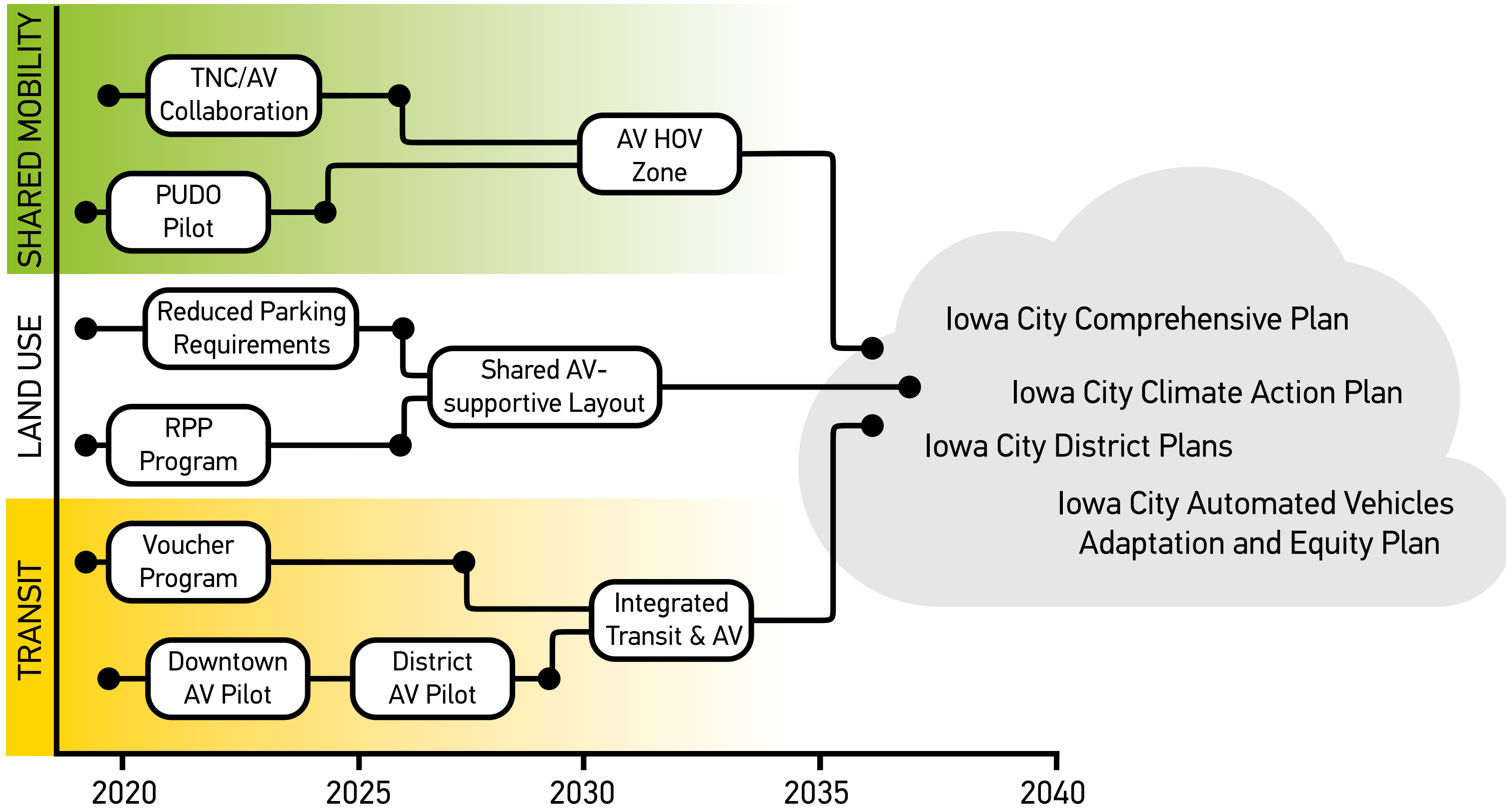


Figure 2: Recommendations timeline (Source: Authors)

• Create public-private partnerships to allow shared mobility modes to complement Iowa City transit. First of all, integrate the BONGO app with shared mobility service providers to establish a data repository that assists in understanding residential travel patterns. Secondly, encourage shared mobility operators to enter into data-sharing agreements. Finally, encourage Transportation Network Companies to offer a mandated level of service in Iowa City's mobility-challenged areas.

Iowa City Transit

• Redesign the future Iowa City Transit system as a trunk and feeder system that utilizes neighborhood door-to-door AV shuttles that feed dedicated trunk lines moving a high volume of passengers across the City.

• Implement an AV shuttle pilot in the downtown area to allow residents an opportunity to explore AV technology.

• Implement a rideshare voucher program to offer mobility services for disadvantaged residents when transit is not in service.

Parking and Land Use

• Implement a Residential Parking Permit Program to address spillover parking challenges in neighborhoods with close proximity to the downtown area.

• Reduce parking requirements to increase the quality of Iowa City's built environment and improve housing affordability.

• Revise zoning and subdivision regulations to encourage active and shared mobility infrastructure in future residential and commercial developments.

Included in the plan is a value proposition that presents two scenarios for future transit usage and compares the ridership, service areas, vehicle miles traveled, greenhouse gas, and public health implications associated with a "Business as Usual" approach in which Iowa City Transit maintains its current system versus transitioning into the "Automated Transit Fleet" scenario that sees a fixed-route trunk system fed by neighborhood AV shuttles. These scenarios are translated into a vision for the future that was presented to the public in an open house event so that their input could be incorporated into the plan's policy interventions. The plan concludes with a discussion of how the policy interventions connect to the City's Comprehensive Plan, Climate Action Plan, District Plans, and the Johnson County Long Range Transportation Plan.

Transportation technologies, especially those related to automated vehicles, will continue to develop rapidly. The City of Iowa City is in a position to be a leader among mid-sized communities in planning for the potential impacts associated with AVs; through leveraging existing assets and addressing the current mobility challenges of residents, Iowa City can foster a more efficient transportation system that offers mobility options that allow all residents access to the myriad economic opportunities and amenities the City has to offer.

IOWA CITY ON THE MOVE

WHY PLAN FOR AV?

Recent developments in automated vehicles and associated technologies have begun shifting the way we think about transportation. Communities across the United States are beginning to consider what their future transportation systems can look like with the integration of automated vehicles as well as the role they want automated vehicles to play in their urban landscape. With benefits like increased road safety, increased access to transportation options, decreased congestion, and decreased greenhouse gas emissions, automated vehicles could play an integral role in shaping future transportation networks that offer the efficiency and equity outcomes we strive for.

However, it can be easy to overlook the prospective challenges brought about by automated vehicles. If communities do not properly plan to adapt to automated vehicles, they could see urban sprawl as the time-savings related to traveling in a driverless car could incentivize people to live farther from their jobs, increased inequity in transportation access if the majority of automated vehicles operating in public roadways are privately owned, declines in public transit ridership that could lead communities to ending their provision of the service, and the degradation of pedestrian-oriented areas as the use of automated vehicles to drop users off wherever they'd like could result in less walking overall.

OVERVIEW OF AV

Driver assistance technology has existed in vehicles since the 1950s. (NHTSA, 2018). From 1950 to 2000, these technologies included safety and convenience features like cruise control, seat belts, and antilock brakes. The next decade (2000-2010) added advanced safety features such as electronic stability control, blind spot detection, forward collision warning, and lane departure warning. From 2010 to 2016, advanced driver assistance features were added. These features included rearview video systems, automatic emergency braking, pedestrian automatic emergency braking, rear automatic emergency braking, rear cross traffic alerts, and lane centering assistance. Our technology now (2016-2025) is evolving to include partially automated safety features that include lane keeping assistance, adaptive cruise control, traffic jam assistance, and self-parking capabilities. Expected evolutionary technologies beyond year 2025 include fully automated safety features that include the highway autopilot (NHTSA, 2018).

Nomenclature is critical for cohesion and consistency; however, the industry is still formulating terminology for universal compatibility. Meanwhile, the U.S. Department of Transportation (US DOT) has devised a variety of terms and generalized language. This report shall follow suit with current trends in federal language.

Clear and consistent definition and use of terminology is critical to advancing the discussion around automation. To date, a variety of terms (e.g., self-driving, autonomous, driverless, highly automated) have been used by industry, government, and observers to describe various forms of automation in surface transportation. While no terminology is correct or incorrect, this document uses "automation" and "automated vehicles" as general terms to broadly describe the topic, with more specific language, such as "Automated Driving System" or "ADS" used when appropriate. See page 7 for a full glossary of terms ("USDOT Automated Vehicles 3.0 Activities" 2018).

One day the evolution of ADS will be able to handle the task of driving when it is not possible or desired for individuals to drive. Today's ADS uses hardware (sensors, radar, and cameras) and software to help the vehicle identify safety risks and avoid traffic collisions by alerting the driver when a potential risk is identified by the system. ADS helps drivers to avoid unsafe lane changes and avoid drifting out of their current travel lane. ADS also warns drivers of vehicles of obstacles behind them while traveling in reverse. Vehicles are now able to brake automatically when a vehicle ahead has stopped or slowed down suddenly.

There are six levels of ADS, according to the Society of Automotive Engineers (SAE). Level 0 has zero autonomy, and the driver performs all driving tasks. In Level 1, the vehicle is controlled by the driver at all times while some driving assistance features may be included, such as cruise control. Level 2 ADS includes partial automation where the vehicle has a combination of automated capabilities, either longitudinally or latitudinally, but not both simultaneously. These include acceleration and steering assistance, and like Level 1, the driver must be in control and engaged at all times to monitor environmental conditions. Level 3 is regarded as conditional automation. The driver's attention is still a necessity at this level, but only for vehicle takeover when notified by the system. Level 4 is considered high automation. This vehicle is capable of performing all driving tasks under specific conditions, but the driver may have to take control of the vehicle at any moment. Level 5 is full automation where the vehicle is capable of performing all driving tasks in any condition. At this level there is an option for the driver to take control, however, the human occupants are simply passengers and need not be involved in driving. Currently we are in a transition phase between level 2 and 3, most notably with the availability of ADS technology in Tesla vehicles.

The benefits of automation include safety, economic and societal efficiency and convenience, and improved mobility. Safety is regarded as the main benefit associated with AVs and these vehicles have the potential to save lives and reduce injuries. In 2017, the U.S. economy lost $242 billion in activity and $57.6 billion in lost workplace productivity, as well as $594 billion due to loss of life and decreased quality of life due to injuries. Additionally, Americans spent an estimated 6.9 billion hours in traffic delays in 2014. A recent study suggests that when automated vehicles become popular (beyond 2030), they are estimated at possibly freeing up as much as 50 minutes per day in travel efficiency (Bertoncello & Wee, 2015). This could increase family time and reduce vehicle emissions and fuel costs. Automated vehicles could also extend mobility options for the 53 million disabled people as well as 49 million Americans who are over the age of 65. This technology could also have the potential to create employment opportunities for nearly two million disabled people (NHTSA, 2018).

BENEFITS & CHALLENGES OF AV

While improved safety is touted as the major benefit associated with the deployment of automated vehicles, there exist a range of other benefits and challenges. The team performed a comprehensive literature review of different scholarly articles to identify the potential impacts of automated vehicles on future urban landscapes. It was found that AVs can provide myriad benefits to future communities, however, these benefits are not without various challenges that will rely on sound planning practices to resolve.

The bulk of the academic literature reviewed by the team posits safety improvements as the most important benefit that AVs will provide. AV technologies, especially those related to safety, are improved upon annually which will lead to the eventual availability of level 5 technology—otherwise known as completely self-driving automobiles. This scenario may provide an overall safer transportation network as less vehicles operating on public roadways will reduce the chance of collisions; additionally, researchers have demonstrated that the majority of

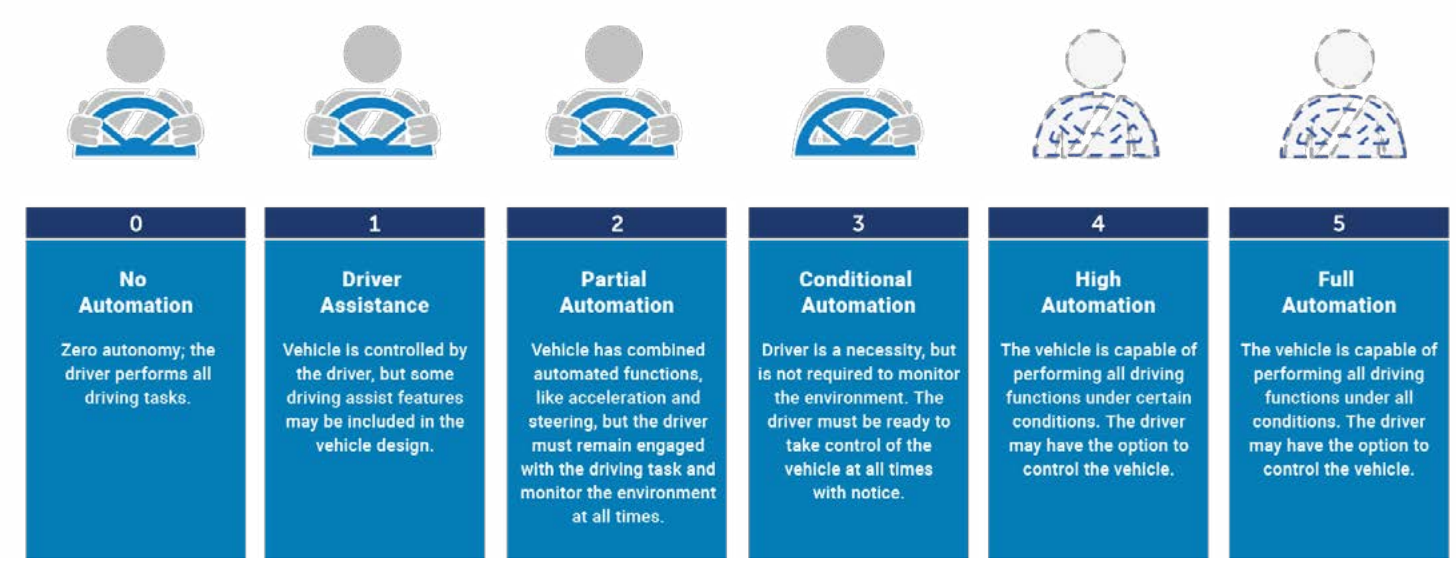


Figure 3: 6 levels of automation (Source: SAE)

automobile accidents occur due to human error (Bagloee, Tavana, Asadi & Oliver, 2016). By removing the human error element, self-learning AVs could be able to provide a social benefit of $2,000 (in 2015 dollars) per AV in terms of crash savings, travel time reduction, improved fuel efficiency, and parking benefits (Fagnant and Kockelman, 2015). AVs can aid cities in achieving lower greenhouse gas (GHG) emissions goals as all AVs are anticipated to be electric vehicles with vehicle to vehicle communication systems on board that will result in higher efficiency in driving and therefore lower emissions. The increasing number of shared AVs (SAV) can provide municipalities with the opportunity to revise their land use control measures to allow for less parking requirements in the downtown areas, which will then give the city authority additional opportunities to convert on-street parking facilities into greenspaces or other land uses. Supplementing the benefits of reduced parking demand provided by SAVs, research suggests that a higher number of SAVs deployed in urban transportation networks can help US households reduce their vehicle ownership needs; researchers estimate that households can reduce the number of vehicles owned from 2.1 to 1.2 vehicles per household (Brandon & Michael, 2017). Vehicle to vehicle communication technology will assist municipalities in managing their transportation network by facilitating more efficient management of intersections, utilizing road space more effectively, and reducing road congestion. Many research findings suggest AVs may help transit agencies minimize their operational costs and allow transit to be more accessible for residents by incorporating AV shuttles into the transit system. Deploying AV shuttles in transit systems may help both transit agencies and TNCs to achieve cost minimization in their operations and make future transportation options more affordable. Therefore, greater equity in municipal transit systems may be achieved with the deployment of AVs in future transit systems.

While the deployment of AVs in urban transportation networks will offer many benefits to municipalities, AVs can also bring about challenges that planners must be prepared to address. The main challenge municipalities will face relates to planning capital improvements - major infrastructure investments will be required to accommodate AVs in the road system, which will pose a significant challenge to municipal and state Department of Transportations' budgets (Governing, 2018). AV technology development is highly dependent on the development of Artificial Intelligence (AI) systems. At the nascent level of the technology, it will be difficult for AVs to cope with adverse environmental conditions such as snow, rain, landslides, etc. Furthermore, driverless technology may cause economic challenges as many industries, especially in transportation, will experience labor market disruptions as the need for commercial highway freight drivers and transit operators will decline drastically. Other concerns include cybersecurity and personal privacy issues due to continuous data collection of riders and surrounding environments (Litman, 2018). Therefore, ensuring security of those large data sets will be a contentious issue as AVs are integrated into transportation networks. Ethical problems may arise with AVs in scenarios involving encounters between other road users and AVs, as the determination of liability in traffic collisions is not clear. Lastly, research finds that the future deployment of AVs may result in a future with increased numbers of cars in the roads and create a new form of congestion termed 'automated congestion" (Descant, 2018).

LEVERAGING OPPORTUNITIES

In creating this adaptation and equity plan, the team assessed the trends in Iowa City's mobility systems to identify the existing challenges, explored the impacts related to automated vehicles, and used those findings to guide Iowa City's sustainable development strategies.

Our focus was guided by the understanding that technological progress is imminent and the deployment of automated vehicles will sooner or later take place in Iowa City, thus it is our role as planners to ensure that this process does not diminish the livelihood of the residents, but rather it enhances their goals and aspirations towards accessibility, sustainability and equity expressed in the City's visioning and planning documents. For years Iowa City has led the U.S. livability charts among cities of a similar size (Wheelwright, 2018), yet it is not free from the prevalence of common transportation challenges facing other U.S. cities like inefficient public transit systems, untamed disruption caused by ride-hailing services and other TNCs, predominance of parking in the urban core and injuries on the roads. On the other hand, general technological change, such as automation, electrification and connectivity already disrupt our society and will potentially influence human lives even more in the years to come. We consider their deployment as a unique pivot to alter the prevailing car-dependent pattern of U.S. urban development that can facilitate improved living conditions and access to opportunities for the people of Iowa City.

Nevertheless, there is no concrete understanding of a timeline and scale for automated vehicles' introduction to local transportation systems, as there is still a gap between existing pilot projects, and assumed potential and actual deployment of operationally sound and safe products. In leveraging the existing knowledge pertaining to AVs we aim to create a flexible framework that lays out the understanding of the benefits and challenges of the new technology, foresees the changes, adapts current planning methods to the expected requirements and avoids unnecessary public expenditures.

PROJECT SCOPE & AIMS

Despite working in the uncharted territory of automated vehicles planning, the team has the support of University faculty, and the Provost's Office of Outreach and Engagement, as well as the guidance of two experienced project partners – the City of Iowa City and the National Advanced Driving Simulator (NADS), a leading transportation research center. Under their guidance, our aims with this plan are to:

- Understand the multimodal accessibility needs of Iowa City residents and identify how AV technology can help meet these needs for all.
- Analyze the benefits of emerging shared mobility technologies, their relations to AV adoption, and their prospective impact on Iowa City.
- Assess the impact of AV and associated mobility technologies on future land use and propose changes designed to improve land use efficiency.
- Evaluate the role AV technology can play in Iowa City's transportation network and assess how it can benefit the community.

PROJECT METHODOLOGY

Through literature review, field work, data analysis, discussions with stakeholders, and a public open house event, the team identifiied and researched the topics of transit, land use, shared mobility and safety as well as assessed stakeholders' perspectives towards autonomous technology to inform the baseline for scenario planning and provide short- and long-term recommendations for the city.

This part of the report aims to describe the overall approach to the plan's creation, while the methodology for concrete steps, whether through research, analysis, or public input, is discussed in the corresponding sections.

Despite the vigorous discussion in academic and pro-

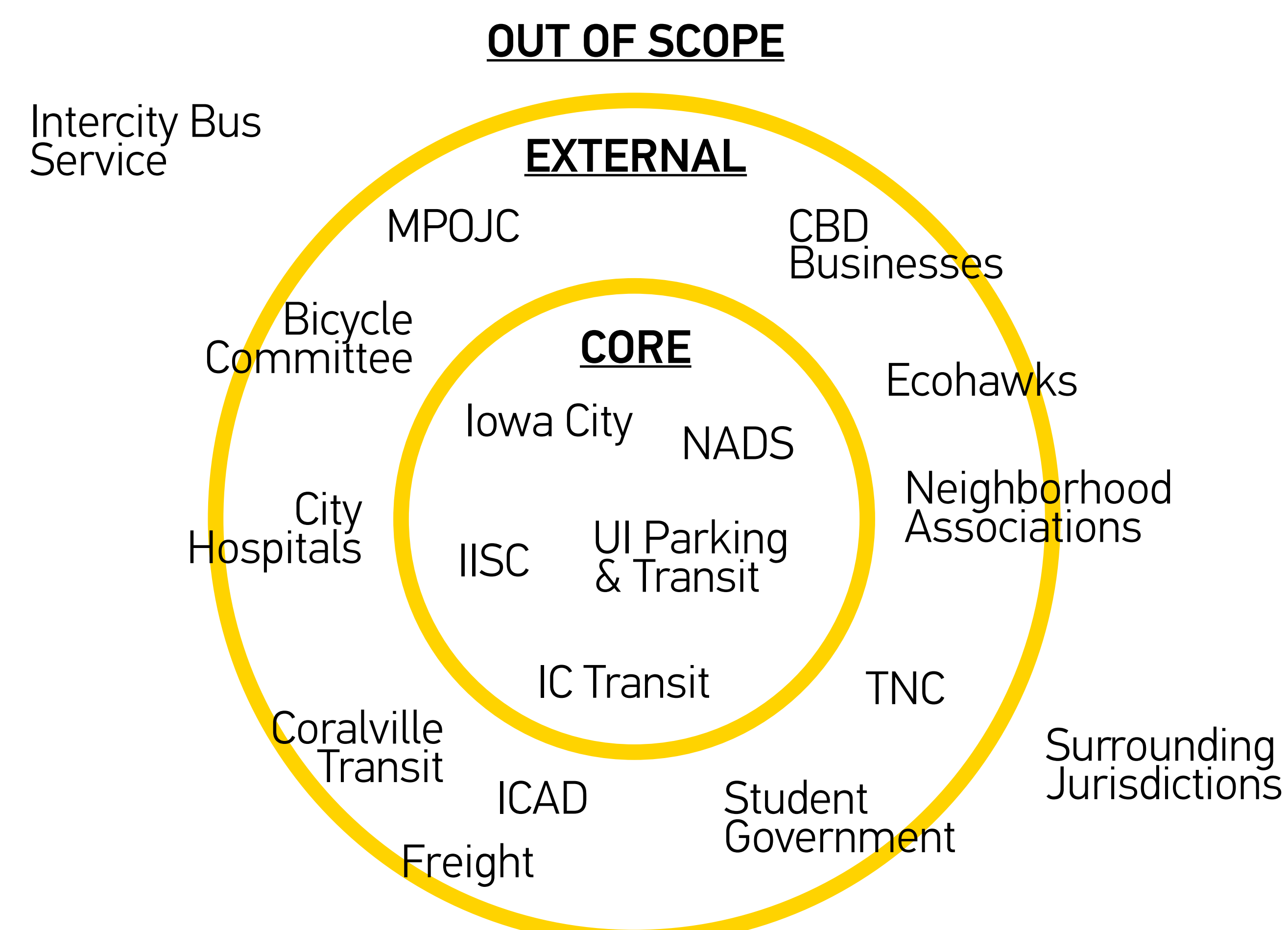


Figure 4: Project stakeholders (Source: Authors)

fessional circles as well as numerous media publications and public events, to the project's team best knowledge, there is no comprehensive methodology or existing best practices that can be replicated in our attempt to plan for automated vehicles in Iowa City. Researchers across institutions assess the perception of and propensity to use AVs through focus groups and surveys (Nielsen, 2018) or model the impact of expected benefits and externalities on the built environment (Zhanga, 2015) while practitioners suggest engaging communities in the discussion and thinking on the topic through the process of scenario planning (Nisenson, 2018). Following suggestions from the latter, the team's approach to the project stems from the Federal Highway Administration (FHWA) Scenario Planning Guidebook, which establishes the framework for providing support for transportation agencies in planning for population and land-use changes, climate change, and transportation network resiliency. The proposed six-phase framework raises pertinent questions, advises actions and strategies, and outlines the potential outcomes for each of the steps discussed (FHWA, 2011). It should be noted, that although the team doesn't employ the FHWA methodology in full, it agrees that this technique is instrumental when planning for the uncertainty of the future.

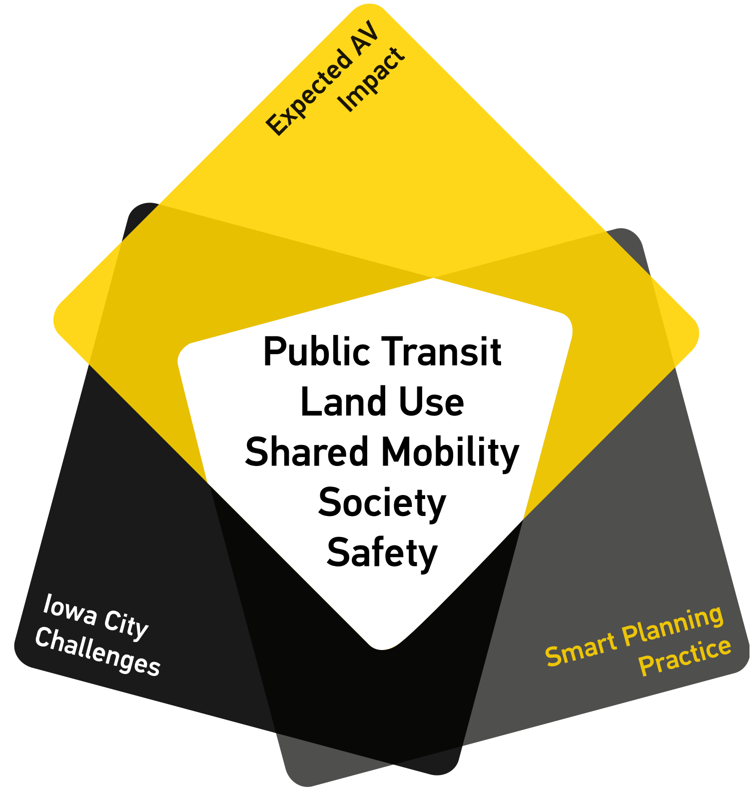


Figure 5: Research topics (Source: Authors)

Once aligned with the aims and expectations outlined by the project partners, the team transformed the methodology from the FHWA Scenario Planning Guidebook into a five-step process that structures the existing research attempts and planning techniques to create a comprehensive framework that measures the effectiveness of the existing transportation network, adjusts to the equity challenges, assesses the public sentiment towards automated vehicles, and guides the decision-making process that can then be applied by the City of Iowa City both in a short- and long-term perspective.

At the first stage we reviewed Iowa City planning documents and the existing body of AV-related literature that incorporated professional planning knowledge to allow for the identification of the four topics that required further field research and data analysis for the project. These four topics are: public transit and land use challenges, shared mobility trends, societal knowledge and expectations, and safety challenges.

The third step of the process synthesizes the conclusions of the first two stages and informs the development of a 5-year Short-term Mobility Improvement Plan that is aimed to improve the current transportation network of Iowa City while providing solutions to the current mobility challenges facing Iowa City residents. These very conclusions provide a basis for the scenario planning activities conducted in accordance with the FHWA Scenario Planning Guidebook recommendations.

The no change and vision scenarios created by the planning team were presented to the general public for a round of comments to again verify the relevance of the team's proposals to the residents' aspirations and once altered to that input, these scenarios completed the fourth stage of our project. The ultimate goal at this point was to explore the future uncertainty in order to prepare the resilient answers to the numerous challenges of the years to come (Schwartz, 1996) and set a foundation for the long-term recommendations, summarized in the Future shared mobility plan developed during the fifth step.

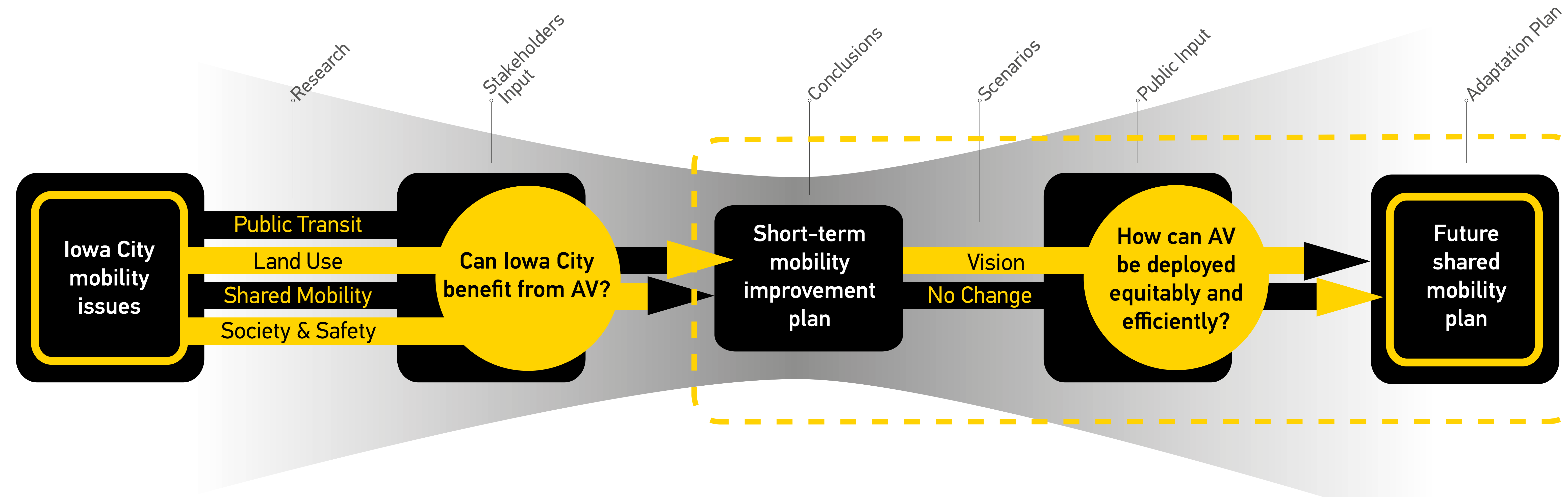


Figure 6: Project methodology (Source: Authors)

TRANSPORTATION IN IOWA CITY PLANNING DOCUMENTS

The team reviewed the most current Iowa City planning documents to establish a baseline for understanding both the main mobility challenges and desires that residents face and share. Transit and parking are the topics that require further research for the purpose of this adaptation plan.

The transportation section of the current comprehensive plan of Iowa City, IC 2030, provides an exemplary list of goals that express the community's desire to have a multimodal transportation system that does not compromise the social and natural environment of the city (Iowa City, 2013). The Complete Streets Policy, adopted in 2015, guides the coordination of development and roadway improvements in a manner that complements all modes of transportation, including motorized vehicles, transit, pedestrians, and bicyclists (Iowa City, 2015). Furthermore, the desire for walkable and bicycle-friendly streets is not only communicated in IC 2030, but it is outlined extensively in the Metropolitan Bicycle Master Plan (Johnson County Council of Governments, 2009).

While IC 2030 discusses opportunities to increase public transit ridership and better integration with the transit systems of neighboring jurisdictions (Iowa City, 2013), the newly presented Climate Action and Adaptation Plan emphasizes the importance of concrete actions in this direction if the city wishes to reduce its footprint (Iowa City, 2018). The Climate Action and Adaptation Plan highlights the necessity for effective management and planning for the parking options, while District Plans further this sentiment through the identification of the streets that face pressure from the parking spillover of the central business district and thus require policy intervention (Department of Planning and Community Development, 2008).

IC 2030 articulates goals related to compact development and an accessible, pedestrian-oriented downtown in its land use section while acknowledging the potential economic effects from thoughtful and innovative investment in transportation and associated land use decisions (Iowa City, 2013). However, it's the Climate Action and Adaptation plan that vocalizes community's commitment towards sustainable modes of transportation, change of travel patterns, use of electric vehicles and streets accessible for everyone (Iowa City, 2018).

Though this research doesn't focus on the regional scale due to time and resource constraints, the team reviewed Johnson County MPO's Long Range Transportation Plan to better accommodate the topics that are important not only for Iowa City itself but have a significant impact on neighboring jurisdictions. The analysis conducted found no contradictions with the planning documents mentioned above, but rather reiterations of the goals already discussed, like the development of a multimodal transportation system, integration of neighboring transit networks, enhancement of the quality of life and attention to safety and equity in the area (Johnson County MPO, 2012).

All these documents comprise the result of a long and extensive participatory process, which ensures that the aforementioned findings represent both the challenges and aspirations of the community, and thus served as a starting point for the team's further research and planning for the adaptation of automated vehicles in Iowa City.

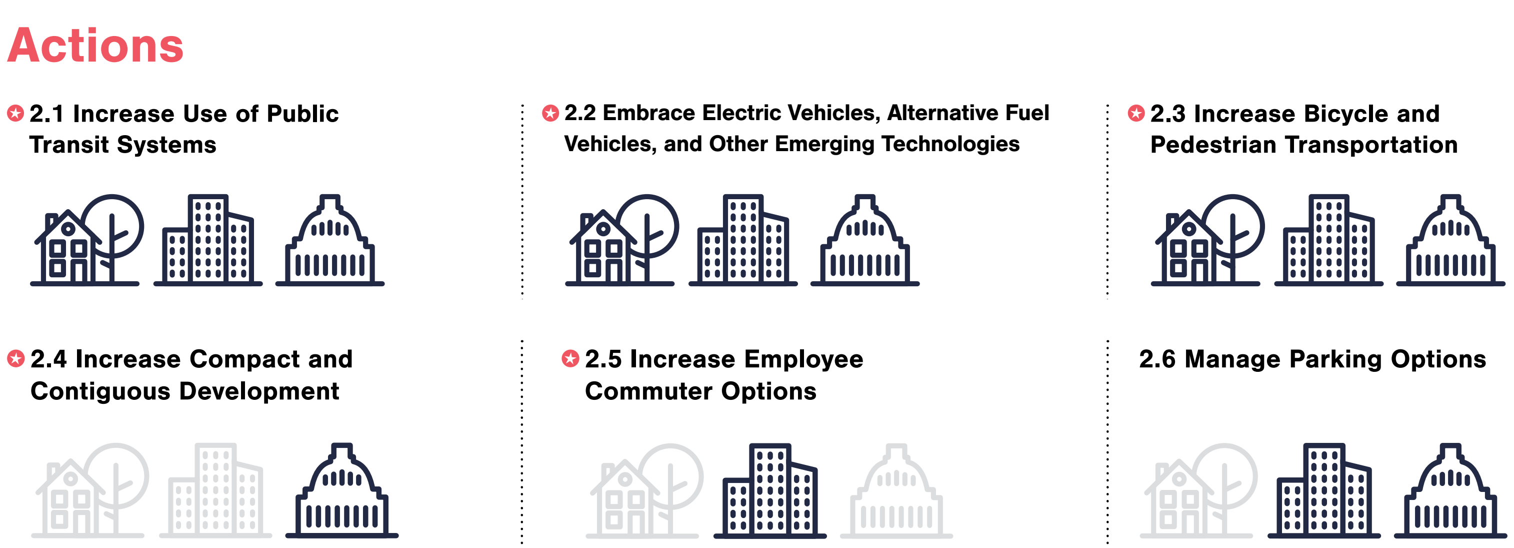


Figure 7: Iowa City Climate Action Plan transportation goals (Source: Iowa City)

THE NEW MOBILITY

ADAPTING TO CHALLENGES

Full deployment of automated vehicle fleets is not expected to occur within the next 20 years, and this fact presents challenges to planners and the communities they serve. The main difficulty lies in the many unknowns surrounding the integration of this technology in local transportation networks and the effects AVs will exert on land use, city services, capital improvements, and transit options, just to name a few. Nevertheless, planners should consider the role AVs will play in future urban landscapes while working towards the vision and goals set forth in their community's planning documents. By meeting the current needs of their residents within the projected scope of automated vehicle deployment, communities may set the appropriate stage for a seamless integration of AVs in the future. The planning team, informed by the guidance of project partners and stakeholders, authored short-term mobility recommendations to address the current mobility needs of Iowa City residents, provide guidence for the city's future planning activities and anticipate the benefits of automated vehicles. The structure of research and recommendations builds upon the aspect of new mobility identified in the report—shared mobility and safety, strengthened transit, as well as effective asset management—to deliver a set of policy recommendations that will further Iowa City's vision for a more sustainable future. The focus of the plan is:

- Provide incremental improvements of transit in Iowa City, including the economic and equity analysis of a rideshare voucher program for disadvantaged households in the city, and allow for the integration of automated technology in the future transit system.
- Guide the improvement of city parking policies and their adaptation to the efficient and safe operation of automated vehicles by evaluating the potential for a residential parking permit program as a way to effectively manage existing community assets, provide guidence for the reduction of parking requirements and transit supportive layouts for new developments.
- Design of a ridesharing mobility program that offers guidelines for collaboration between Iowa City and TNCs, including data sharing programs with the City and other innovative solutions for more informed planning regarding this emerging approach to transportation.
- The development of a pick-up and drop-off management plan for the downtown area to facilitate a more efficient flow of TNCs and better synchronize commercial delivery activities with optimal loading and unloading times that shall pave the ground for the safe and equitable operation of automated vehicles in the future.

TRANSPORTATION EQUITY & AV

One major benefit associated with emerging transportation technologies, such as AVs, is that they can be leveraged to provide more equitable outcomes for disadvantaged households through providing more inexpensive mobility options that increase residential access to economic opportunities and other amenities within communities. However, if not properly planned for, these technologies could serve to exacerbate existing inequality in transportation systems. Unregulated AVs could encourage sprawl and increase transportation costs which could burden low-income households. A greater proliferation of shared mobility modes could lead to unequal service areas as disadvantaged residents who lack access to the technology required to use them are unable to utilize these mobility options. An additional concern with shared mobility is that emerging shared modes, such as bikesharing and TNCs could replace transit trips in communities, resulting in declining transit service and further impacting low-income households who rely on public transit as their main means of transportation. Finally, research suggests that disadvantaged communities see higher rates of pedestrian and bicycle collisions so integrating AVs into local transportation systems without making safer infrastructure improvements could pose significant risks to safety in these areas. To address these equity concerns, planners and the communities they serve should begin to plan for AVs and associated technologies by ensuring that disadvantaged residents are involved in the planning process from the very beginning and these individuals have a say in deciding what role AVs will play in their urban landscape.

Equity is a major concern in any planning project and addressing equity concerns is a challenge communities face as measures of equity vary across spatial contexts and project purposes. In transportation planning, equity can be broadly viewed as access to quality services that increase individual's economic and social opportunities, management of externalities related to transportation, the allocation of public resources for transportation networks, and the outcomes of land use decisions that shape residential development patterns (Litman, 2002). While equity is not limited to just these factors, this plan outlines how Iowa City can address its current mobility challenges while paying due consideration to facilitating equitable outcomes related to existing and future transportation planning decisions.

Within the scope of this project, the planning team defines equity in Iowa City's transportation system as the provision of quality transportation services that increase residents' access to economic and social opportunities, especially for residents who face difficulty in accessing mobility options during peak and off-peak hours. To assess equity outcomes for the policy interventions set forth in this project, the team created an equity matrix. The first metric looks at the accessibility to shared modes by Iowa City residents; the specific measure is the level of shared mobility options (including transit) accessible to Iowa City residents throughout the city. To ensure equity with regard to safety, the team delineated a second metric that measures the percentage of active transportation infrastructure that provides greater safety to all road users (i.e. protected bicycle lanes) located in lower-income areas. Currently, there is no data to analyze the City's progress of the bicycle plan implementation, though it's expected that with its execution, the percentage of active infrastructure in the City will increase. The third metric of the equity matrix looks at the City's public Capital Improvement Plan to provide equitable outcomes in infrastructure decisions. While the team didn't assess how the city allocates funds to different segments of road users, based on the historical trends in the U.S., it is expected that they are skewed towards automobiles, thus it is hoped that moving forward, a more balanced approach will be executed. The final metric of the equity matrix is linked to transit access for Iowa City residents, specifically, the proximity of Iowa City residents to transit stops located in their neighborhoods. Through maximizing the number of residents within a 5-minute walk to the nearest transit stop, the City of Iowa City can further ensure that all residents have access to a transportation option without depending on a private vehicle for travel.

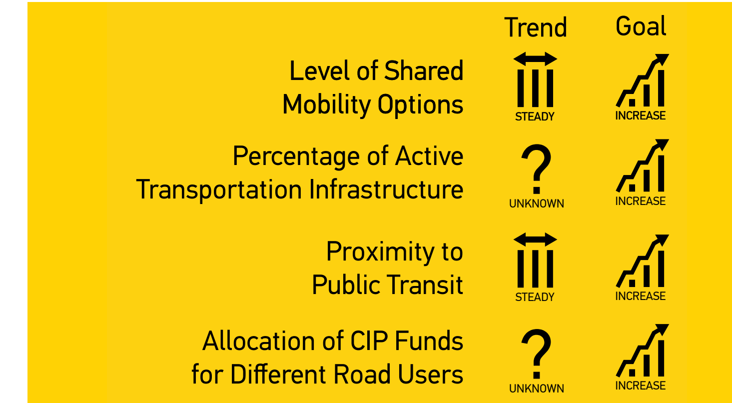


Figure 8: Equity matrix (Source: Authors)

The incorporation of automated vehicles in the transit system and value the proposition for transit are expected to significantly increase the level of access to shared mobility in the City. Additionally, the proximity to transit services will increase due to the expansion of the transit service areas and door-to-door feeder services. Also, the distributional equity of the CIP funds will improve due to this value proposition. More people will be likely to use transit and therefore, more investment in the transit development will be equitable.

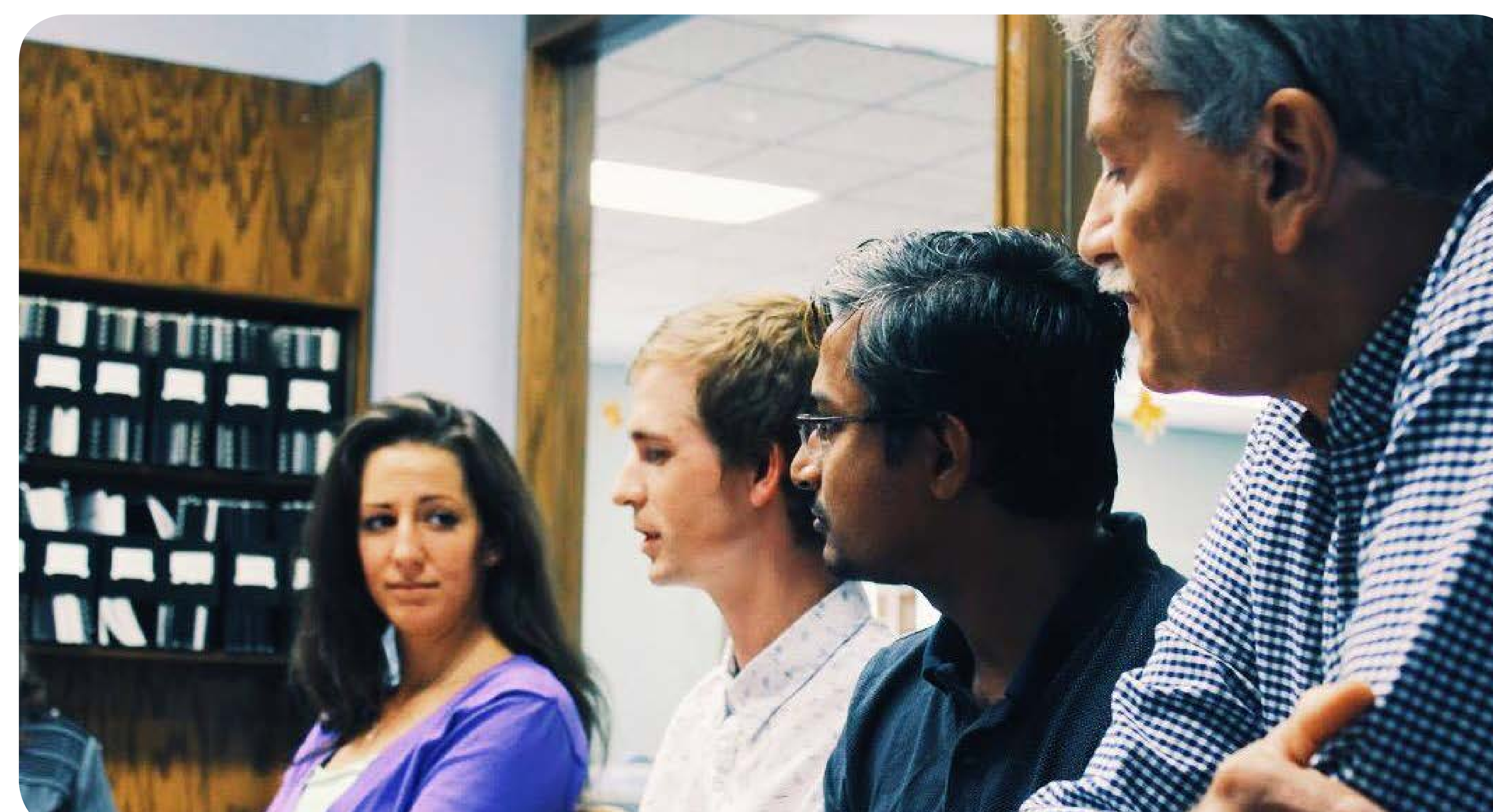


Figure 9: Project meeting (Source: UI Office of Outreach and Engagement)

PREVIOUS RESEARCH ON PUBLIC PERCEPTIONS OF AV

The team studied numerous research papers, opinion columns and books, attended a number of professional conferences, and interviewed community leaders, transportation officials and automotive experts. Altogether, this research contributed to the understanding of the inevitable deployment of AVs in public roadways, yet, there is much debate amongst researchers regarding when AVs will be fully deployed. This section of the report aims to discuss some of the previous findings on public opinion regarding autonomous vehicles in the U.S., and to present the qualitative input the team received from various city stakeholders over the course of the study.

A number of the most recent studies are consistent in their conclusions on the positive public opinion surrounding fully automated vehicles. A 2012 survey of 17,400 U.S. drivers revealed that more than a third of respondents were eager to purchase "a feature that allows the vehicle to take control of acceleration, braking and steering, without any human interaction," which was reduced to only 20% once the estimated cost of an additional $3,000 per vehicle was announced (Power, 2012). The two studies that followed the initial one surveyed more than 15,000 users each and achieved similar results (Power, J. D., 2013; Youngs, 2014).

Ten focus-groups consisting of 32 people over 21 years old from three U.S. states – California, Illinois and New Jersey - revealed that women were more apt to use to driverless vehicles compared to men, while Californians were twice as willing to use it as Illinoisans. Most importantly, the study concluded on the shift of focus from car design, engine and driving performance to the issues of safety, trust and technological advancement during the discussion of self-driving vehicles (KPMG, 2013). Safety was also an important factor in determining propensity to use self-driving vehicles among 467 students of Worcester Polytechnic Institute. Two thirds of the respondents expressed no desire to spend more than $4,999 extra for an automated car, and men prevailed in that share (Casley, 2013).

Finally, even with the negative coverage that flooded the media after a number of crashes involving driverless pilot test vehicles as well as vehicles equipped with Level 2 ADS, the public sentiment towards driverless vehicles remains positive, as Cox Automotive reports. Research shows that more than a half of respondents agree that existing ADS advances people's driving skills, however, only 16% percent would be willing to give up the option of manual driving. Safety is still a top concern for 1,250 participants from the U.S. who took part in online survey that emphasized the importance of real-world testing, but more than half of respondents would prefer those experiments to be conducted outside the areas in which they live (Cox Automotive, 2018).

STAKEHOLDER INTERVIEWS

Being informed by the conclusions of these U.S. studies, and due to the time and resource limits that impeded the conduction of a random-sampled survey, the team focused on carrying out a series of structured interviews with city officials, industry representatives and community leaders to expand on the quantitative findings of this report, as well as to understand the impacts of driverless vehicles on the city in general, and its most vulnerable population in particular.

The objective of conducting stakeholder interviews was to better understand the insights of community leaders and industry experts regarding the mobility challenges of Iowa City residents as well as their perceptions surrounding the potential role automated vehicles could play in the local transportation system. In meeting this objective, the team was able to better inform the planning process and create the basis for a community-wide vision that was presented in a public open house. It was the goal of the planning team to incorporate stakeholder feedback into the plan so that it may serve as a guide for Iowa City in moving toward a predictable, equitable and safe transportation system for residents now and in the future. 14 key stakeholders were identified as representatives who hold a unique and knowledgeable insight into the community and the transportation challenges facing residents. The stakeholders represent the following categories (see Appendices for full list of stakeholder participants): transit-challenged individuals, residents and travelers with disabilities, students, bicyclists, neighborhood representatives, the county's metropolitan planning organization, the chamber of commerce, automated vehicle development and testing, and local freight operators. We summarized the results of the interviews to ten topics that fall into two main categories: challenges and needs.

STAKEHOLDERS ON CHALLENGES

1. Without alternative transportation options and regulations on automated vehicles, private ownership will increase.

- More vehicles on the roadways may lead to more risk of injury to vulnerable road users, such as pedestrians and bicyclists.
- Increased vehicle miles traveled (VMT) may lead to increased cost in the City's operations and maintenance of the roads.
- A potential for increased public health risk via air pollution related to transportation emissions.

2. Transit challenges may be exacerbated as TNC services become more prevalent.

- Transit ridership may see further declines as the first- and last-mile problem with transit is solved through door-to-door TNC service.
- A lack of shared alternative modes may lead to increased transit challenges.

3. Mobility challenged individuals may become further disadvantaged, especially in low-service areas.

- The first- and last-mile gap in transit options further exacerbates the problem experienced by mobility challenged populations who are out of the transit service area.
- Transit service areas are costly to expand and decreasing ridership levels due to competition with TNCs could allow this challenge to persist.

4. Participants believed the transit system costs too much in terms of time savings.

- Time-consuming commutes and inefficient routes reduce the desirability of choice riders and increase hardship on captive riders.
- Iowa City's transit routes are centralized-- all routes go to a hub downtown and then to the outer regions of the city.
- Transit routes are indirect and funnel through downtown. Many riders simply wish to go from work to home, without rerouting to downtown.
- Long commute times with limited transit and an increasing population may further exacerbate these hardships and undesirable conditions.

5. Iowa City's transit system is fragmented and traveling outside the City is a difficult process.

- The fare system requires riders to purchase a separate ticket for each transit service. For example, a resident that lives in Iowa City and works in Coralville, approximately two to five miles away, must purchase two separate tickets for both operators (Iowa City transit and Coralville transit) each way.

STAKEHOLDERS ON NEEDS

1. Preserve and nurture Iowa City's walking and biking lifestyle.

- Iowa City is bicycle and pedestrian friendly. The city's pedestrian-friendly environment is a major asset and should be maintained in future planning projects.
- The City's residents and stakeholders take pride in the active lifestyle that is embedded in the culture, and they want it to remain so.

2. Expanded transportation options are needed for residents, especially off-time and weekend workers.

- Provide alternative transportation options for private vehicle owners to be comfortable opting out of driving.
- Provide transportation options for residents and travelers who are transportation disadvantaged or living in low-service areas.
- Currently, public transport operates during the daytime into the evening Monday through Saturday. Routes should be served on Sundays or for third shift employees.

3. Expand the range of transit access and provide residents a viable option to travel to employment.

- An increased service in low-service areas will increase the ability of residents to get to and from a place of work, which is vital for steady employment and, therein, well-being.

4. Direct routes for faster commutes.

- Direct routes may increase time savings for riders. This will lead to an increase in desirability for choice riders and reduce the hardship for riders who have no alternatives.

5. Regional and local collaboration in transit services.

- Online options for purchasing tickets, and/ or having tickets which are transferrable could boost transit ridership within Iowa City and the surrounding region.

SHARED MOBILITY

With the continual development of AVs and their prospective impacts on municipalities, it is time for communities to begin exploring the role they will play in the future urban landscape. While the potential benefits of AVs - namely improved road safety, reduced emissions, improved mobility and accessibility for residents - align with the vision and goals of Iowa City set forth in the community's planning documents, the potential challenges of AVs run counter to the City's aims for the future. If not properly addressed in the near-term, AVs could increase congestion, encourage sprawling development, and increase the divide in transportation equity for Iowa City residents. Through the consideration of shared mobility modes in future planning activities, Iowa City can preserve the dense, walkable community the community strives to maintain, especially in the downtown and near-downtown areas, while offering residents transportation options that increase their mobility and accessibility, thus fostering greater equity in transportation services. The careful consideration of shared mobility modes can then mitigate against the potential challenges brought forth through the integration of AVs in the City's urban landscape while supplementing this technology's potential benefits.

SHARED MOBILITY OPTIONS

Shared mobility, defined as transportation resources that are shared among users, either concurrently or one after another (Shared Use Mobility Center, 2018), is revolutionizing how mobility concerns of urban areas are addressed. The advent of smart phone technologies is fostering a connected system of mobility options that is capable of connecting residents to transit or other modal options, reduce traffic congestion, mitigate transportation-related pollution, reduce transportation costs, improve the efficiency of urban transportation networks, and create more equitable mobility outcomes (Parzen, 2015). Currently, there exist a variety of shared mobility modes that are being integrated in large and midsized cities within the United States. These modes include:

• Bike sharing - Public and private programs that provide bicycles and bicycle facilities that are available for the public to rent for a short period of time.

• Carsharing - Private service that offers members access to an automobile for a short period of time.

- Traditional carsharing—Members borrow a vehicle from a specified location and return the vehicle to the same location once their travel needs are satisfied.
- One-way carsharing—Members borrow a vehicle from one location and are free to return the vehicle to any location designated to receive it.
- Peer-to-Peer carsharing—Automobile owners share their vehicle with other members of the service for a specified period of time.
- Niche carsharing—Closed network carsharing programs that serve specific communities.

• Ridesourcing - Transportation Network Companies that utilize mobile or online platforms to link private, non-commercial vehicles with passengers to fulfill travel needs.

• Ridesharing - Network or service of public or private vehicle owners who focus on adding additional passengers in their vehicles to serve travel needs.

- Carpooling - Connects travelers, typically for commuting purposes, to reduce automobile operating costs.
- Vanpooling - Public service that connects commuters to share rides; similar to carpooling but focused on a larger scale.
- Real-time ridesharing—Connects automobile drivers with passengers based on common destinations; connections made through mobile or online platforms.

• Public transit - Publicly owned bus, train, ferries, facilities, and rights of way that provide fixed-route service.

• Scooter sharing - Privately owned fleets of motorized scooters that are available to users for a short period of time.

• Shuttles - Public or private vehicles that serve limited routes; often for employee first- and last-mile needs.

• Microtransit - Similar to transit service, but focused on a smaller scale; utilizes dynamic routes to provide users with a higher willingness to pay for transit.

• Mobility Aggregators - Private companies that offer a bundle of mobility services to users; utilizes a mobile or online platform.

• Courier Network Services- For-hire delivery services of food, packages, etc. Users connect with delivery services via smart phone or online applications.

The majority of research regarding shared mobility identifies several common benefits of these transportation resources. The availability of several shared mobility modes can benefit urban areas by reducing the number of private automobiles in public rights of way, reduce overall vehicle miles traveled on urban transportation networks, provide great accessibility and transportation cost savings to residents, increase catchment areas of public transit operations, and resolve first- and last-mile issues related to public transit (Shaheen and Chan, 2015).

The current status of shared mobility options that exist in Iowa City are presented in Table 1. Table 1 also includes the shared mobility landscape found in other midsized college towns in the United States as well as two major metropolitan areas in the state of Iowa. Iowa City compares reasonably well to the other midsized college towns (Ann Arbor, Austin, Boulder, and Columbus) who are on the leading edge of shared mobility services in the United States. A benefit to the deployment of shared mobility modes in these college towns is that the university systems located within them provide a source of research and innovation that can effectively evaluate the success of these modes in providing additional mobility options in a cost-effective manner for localities; an example of this collaboration is found in Columbus, Ohio, where the city was awarded a grant through the United States Department of Transportation Smart City competition. With the funding awarded by the US DOT, the city of Columbus partnered with the Ohio State University to create Smart Columbus, a data-driven mobility ecosystem that wields innovations in transportation to establish a model for the connected cities of the future (Smart Columbus, 2018).

SHARED MOBILITY LANDSCAPE OF IOWA CITY

• Transit- The Iowa City Transit System, along with Coralville Transit and the University of Iowa CAMBUS system, provides public transit services to residents of Iowa City.

• Carsharing- Zipcar is the only carsharing program currently operating in Iowa City. The program is mainly focused on the student population and three pick-up and return locations exist near campus facilities on both the west and east side of the campus.

• Bikesharing- There is not a bikeshare program currently operating in Iowa City but city officials expect it to start in the Spring of 2019.

• Alternative transportation services - Johnson County S.E.A.T.S. operates within Iowa City and offers paratransit services to residents.

• Shuttles- Iowa City Transit offers free shuttle service from residential areas near the downtown area to the transit hub located in the center of the CBD.

• Ridesourcing/TNCs - Uber and Lyft currently operate in Iowa City.

• E-Hail services- Yellow Cab of Iowa City maintains a smart phone application that allows users to hail taxis and track the location of taxis in real time.

• Courier network services - CHOMP and Grubhub are the two courier network services operating in Iowa City.

• Mobility aggregators - Waze is a route planning and aggregation service available in Iowa City.

While improving upon the shared mobility landscape in Iowa City can realize a number of benefits for residents of the community, the integration of these transportation modes is not suited for every city in the United States. The nature of Iowa City as a midsized college town limits the effectiveness of taxi and one-way carsharing programs as these rely on large cities with major transportation hubs (rail, air, transit) and strong parking management—Iowa City does not meet these requirements. Bikeshare and traditional rideshare programs are feasible within the City as these two shared mobility modes are optimal for connecting residents to transit or other modal options, especially in dense, mixed-use neighborhoods with high pedestrian traffic (Parzen, 2015). Recent research on shared mobility suggests that a shared mobility system is dependent upon five factors in order to sustain itself—population, residential density, mix of uses, proportion of transit users, and walkability (Parzen, 2015). Currently, Iowa City

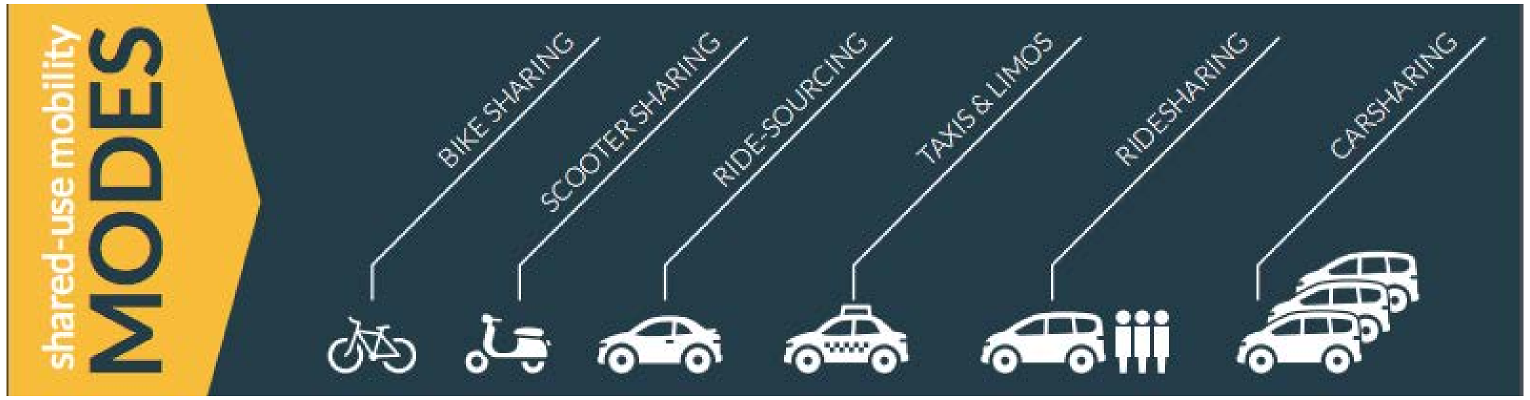


Figure 10: Shared-use mobility modes (Source: SUMC)

meets the minimum for these indicators regarding carsharing and bikesharing.

Planning for shared mobility is a recent activity being undertaken in communities across the United States. Several cities - Los Angeles, Santa Monica, Seattle, and the Twin Cities region of Minnesota - have all adopted shared mobility plans and/or programs. These plans are the first of their kind to be adopted in U.S. cities and highlight the innovative ways some communities are addressing the mobility concerns of their residents. These plans all present the current landscape of shared mobility in their respective cities and present strategies that harness the advantages each city has to offer as they foster a more integrated transportation network that meets the needs of all residents. The City of Iowa City can benefit from emulating these progressive planning activities and adopting their own shared mobility plan that delineates the goals and vision for the community's shared mobility landscape in order to identify the appropriate strategies for improving the current shared mobility options and planning for the future integration of new shared modes, such as bikesharing and scootersharing, in order to provide residents access to the maximum number of shared mobility modes so that current mobility challenges can be addressed and linkages to public transit and future AVs can be established, especially as the new transit study is conducted and the bikeshare program rolls out in 2019.

ENSURED SAFETY

The U.S. Department of Transportation released 2015 data that revealed 35,092 of recorded auto accidents resulted in fatalities, an increase of 7.2% from 2014 (U.S. Department of Transportation, 2016). Driver assistance technologies are already helping drivers to avoid collisions. Current technologies that are improving safety for drivers and bystanders include lane centering and vehicle warnings that signal the driver when making an unsafe lane change. There are also technologies currently employed in new automobiles that signal when a driver has an obstacle in the vehicle's reverse trajectory via cameras, sensors, and radar. Another safety feature of automated vehicle technology is software that helps vehicles to identify potential safety risks that may assist the driver in avoiding a collision.

	Ann Arbor, MI	Austin, TX	Boulder, CO	Cedar Rapids, IA	Columbus, OH	Des Moines, IA	Iowa City, IA
Carsharing	x	x	x	x	x	x	x
Roundtrip carsharing	x	x	x	x	x	x	x
One-way carsharing	x	x	x		x		
Peer-to-peer carsharing	x	x	x		x	x	
Bike sharing	x	x	x		x	x	x
Scooter sharing	x				x		
Alternative Transit Services	x	x	x	x	x	x	x
Shuttles					x	x	x
Microtransit	x	x			x		
Ridesourcing/TNCs	x	x	x	x	x	x	x
e-Hail Services	x	x	x		x	x	x
Courier Network Services	x	x	x	x	x	x	x
Mobility Aggregators	x	x	x	x	x	x	x

Table 1: Shared mobility in the US cities (Source: Authors)

Figure 11: Current landscape of shared mobility options in Iowa City (Source: Authors)

A study by the National Motor Vehicle Crash Causation Survey (NMVCCS) collected information on 5,470 crashes between the years 2005 and 2007. The amount of the crashes in this study that were caused by driver error accounted for 94% of total crashes (NHTSA, 2015). Additionally, in American Public Transportation Association (APTA) news, commuters are assumed to reduce their crash risk by 90% when taking public transit over driving (APTA, 2016). This report observes a study from the authors of The Hidden Traffic Safety Solution: Public Transportation, which shows a decline of auto death and injury rates in communities that have an increase in public transit ridership.

These reports have prompted our safety study of the Iowa City CBD and adjacent areas. The defined area is one that would be most suitable for automated vehicle operations as the technology advances. The northern boundary of this study is E Market Street, then eastward to N Dodge Street, down to the southern boundary of Bowery Street westward joining with E Prentiss Street, and finally the western boundary closes the study area with S Madison Street. Overall, the area is just under a square mile. Due to limited time for analysis, the study area was minimized in order to fully consider as many parameters as possible. The time frame for the analysis spans 2010 until 2018. The baseline year chosen is 2010 because the road infrastructure was updated after the flood of 2008. In this consideration, accidents caused by misperception and changes in habitual travel were not accounted for. The reported and defined accidents available were filtered by major causes, which were filtered again by identifying human error as the major cause. Examples of these variables include: distracted driving, failure to yield to right of way, and failure to obey traffic signals (among many more).

The goal of this analysis was to understand how automated vehicles may enhance safety mechanisms and improve public health and safety. General welfare is another important aspect as time lost due to traffic jams caused by accidents that have resulted from human error in this study area may be reduced. Parameters included are human-caused traffic accidents, pedestrian and bicycle collisions with vehicular traffic, traffic accidents on transit routes, as well as changes in how the road is used.

Since 2010, of the reported accidents in the study area that were defined with a major cause, nearly 2,100 accidents were human-caused. This accounts for more than half of the accidents in the study area. During this time, 179 of the human-caused accidents resulted in one fatality and injuries of major and minor severity. Bicycle and pedestrian accidents amounted to 120 crashes with major and minor injury severity ("Iowa DOT Saver", 2018).

Trends and changes in driving behaviors have become a relevant topic for discussion. Distracted drivers accounted for at least 56 of the reported traffic accidents in the study area since 2010 (Iowa DOT Saver, 2018). Automated Vehicles are designed to increase safety and reduce accidents caused by driver distraction and other human errors. The increase in automation in vehicles may reduce time lost from traffic jams due to these preventable mishaps. TNCs such as Uber and Lyft have altered road usage in a way that has become observably dangerous. This analysis was intended to understand where and at what degree accidents have occurred before Uber and Lyft were allowed to operate. This study also analyzes the occurrences of accidents after their market release. Where accidents occur after the TNCs have been in operation is important since the degree of pick-ups and drop-offs have increased.

As travel behavior has changed in the study area, the pick-up and drop-off locations have become an increasing concern. It is important to understand that drivers are legally allowed to double park to drop passengers off, and to pick up passengers when two lanes are operating in the same direction. This loophole poses a threat to public safety. The allowance may potentially lead to a reduction of efficient traffic flow and increased safety concerns. The team conducted field research during high traffic hours and observed these dangerous activities concerning pick-ups and drop-offs with TNCs, commercial vehicles, personal vehicles, and paratransit services. The observational study pinpointed at least four locations where pick-up and drop-offs occurred regularly. The locations for this observed activity mostly coincided with the traffic crash analysis locations of crash activity. The locations observed to have pick-up and drop-off activity were Iowa Avenue between N Dubuque Street and N Gilbert Street, at the intersection of S Clinton Street and E College Street, another on S Clinton Street between E Washington Street and Iowa Avenue, and on South Dubuque Street at the entrance for the Dubuque Street Parking Ramp. Areas where traffic accidents have increased are on Iowa Avenue between S Linn Street and S Gilbert Street, as well as along many intersections of Burlington Street from E Madison Street to S Dodge Street, especially at S Clinton Street, S Dubuque Street, and S Gilbert Street.

The location of traffic accidents in relation to transit lines for the years 2010-2018 is shown in Figure 12. This is important because of the change in right-of-way use, double parking, and pick-up and drop-off behaviors. The data for Figure 12 was sourced from the City of Iowa City for transit lines and Iowa DOT for the crash data. Transit operations depend on efficient flow and safe road conditions, as do all road users. The transit line data was sourced from the City of Iowa City and the traffic crash data was retrieved from the Iowa Department of Transportation. The joined data shows traffic accidents that occurred on downtown streets and were reported to have been caused predominately by human error. Most accidents downtown occured on roads with access to transit. In the last eight years, at least 2,099 of traffic accidents were reported. From these 1,631 were classified as human-error and on transit routes (see Figure 21). Transit routes are important for reliable and safe public transportation. As mentioned above, an APTA study showed that commuters are likely to reduce their chance of a traffic accident by 90% when taking public transit. It is important as road use changes to adapt appropriate measures for safety, such as a pick-up and drop-off practices with TNCs. It is believe that

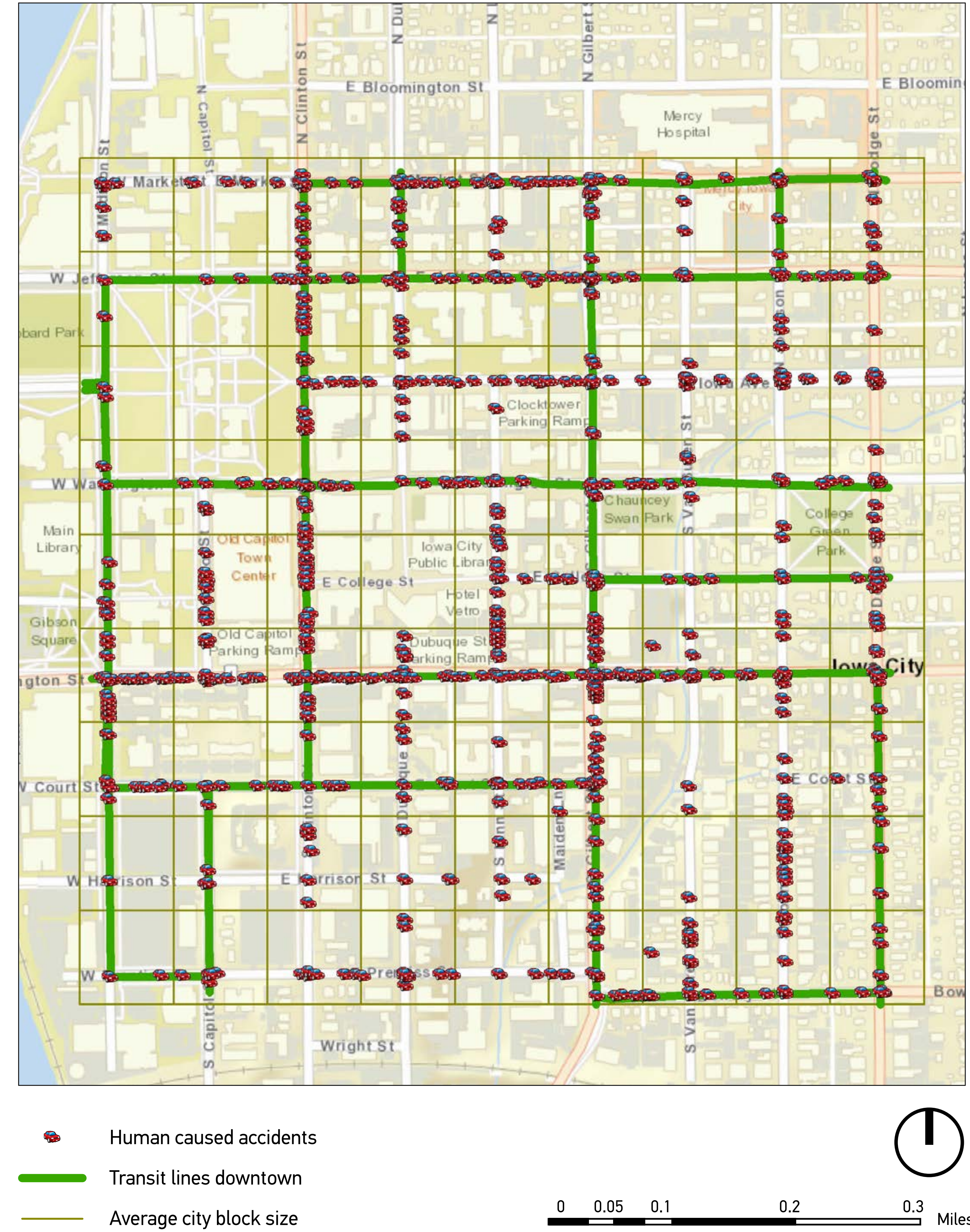


Figure 12: Traffic accidents on transit routes downtown 2010-2018 (Source: Authors)

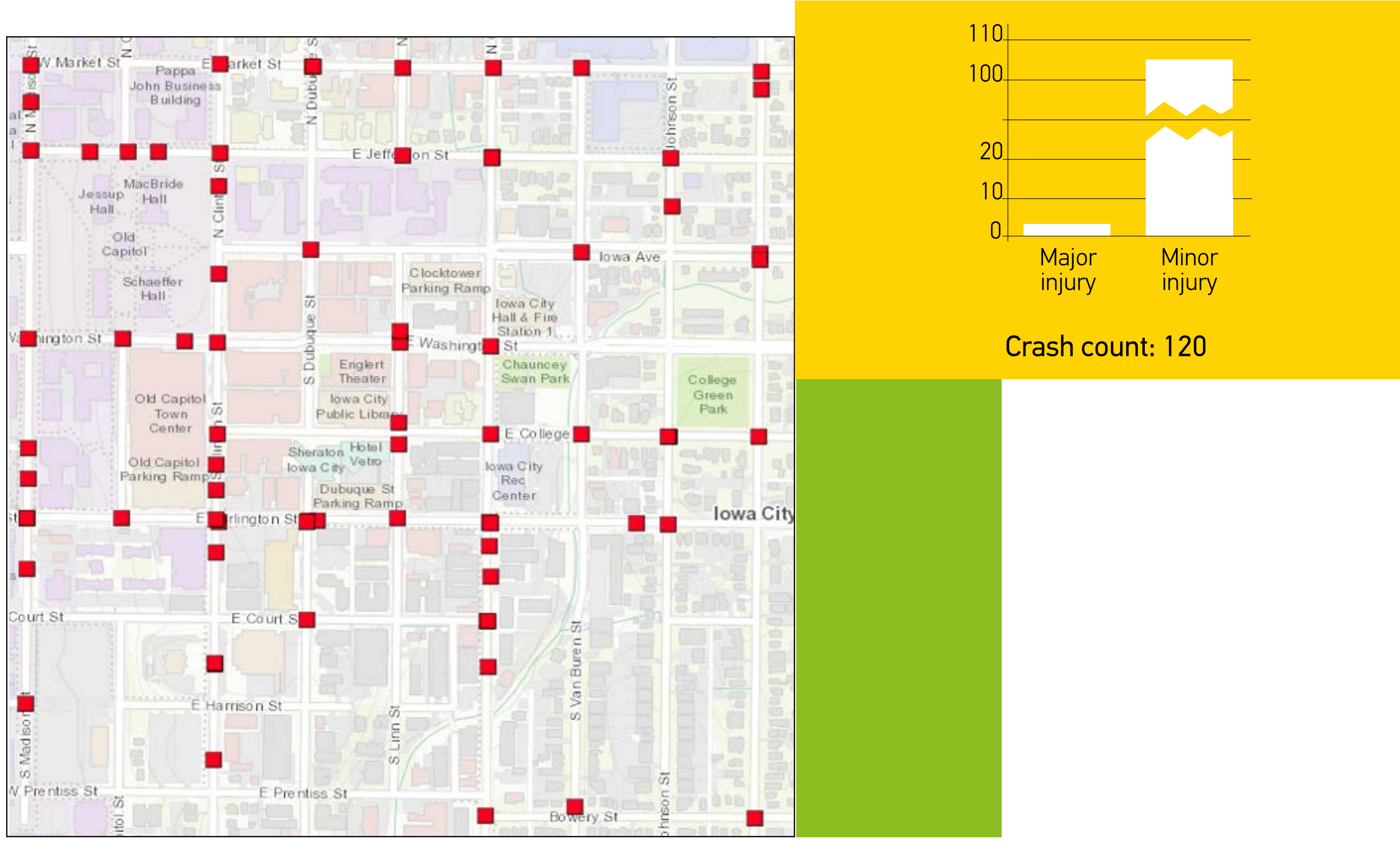


Figure 13: Pedestrian, bicycle, and wheelchair accidents with injury (major & minor) 2010-2018 (Source: Authors)

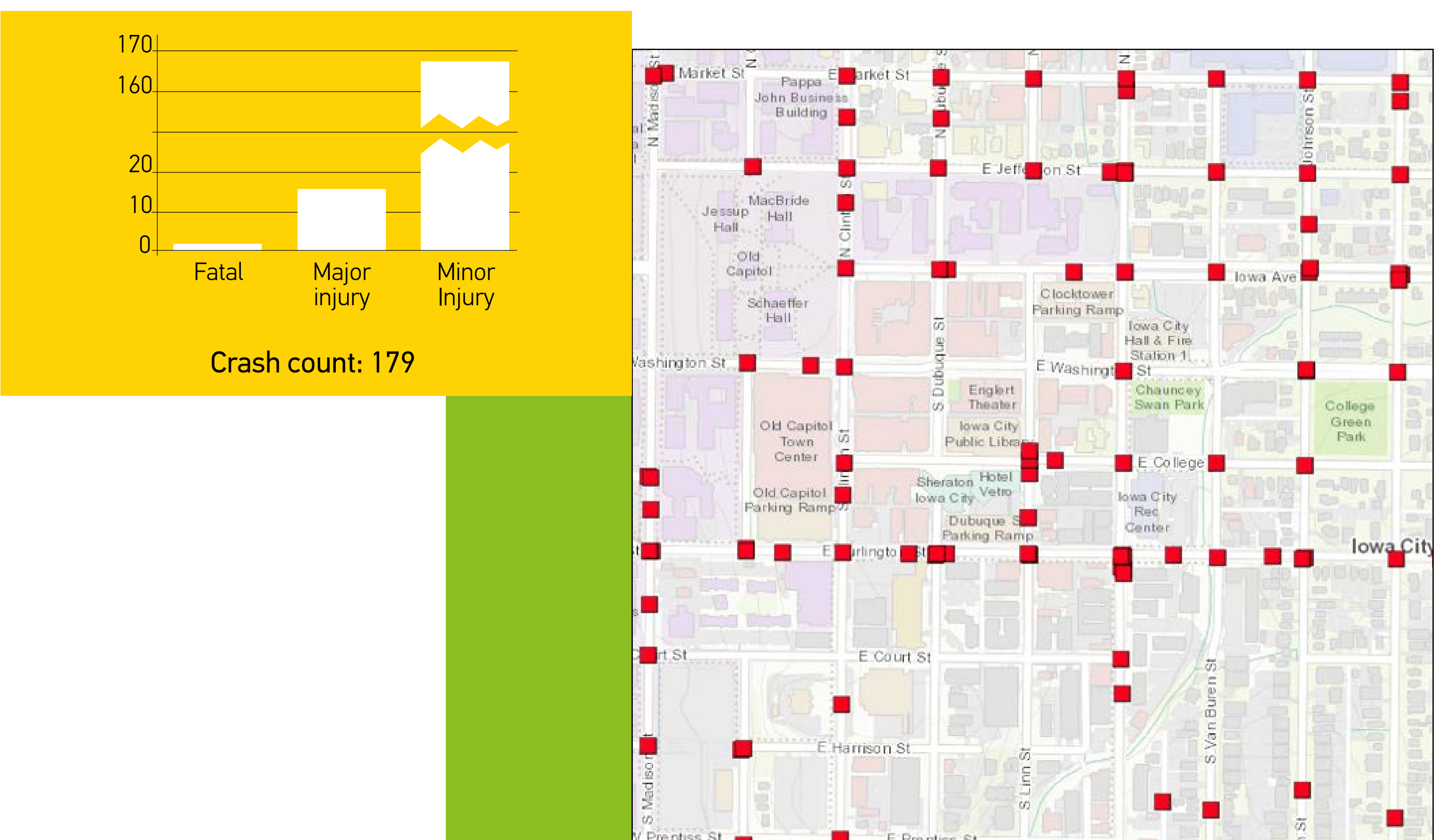


Figure 14: Human-caused accidents with injury reported (fatal, major, & minor) 2010-2018 (Source: Authors)

these communications with both TNCs and commercial drivers may serve a dual purpose; both TNCs for pick-up and drop-off areas as well as commercial vehicles with reliable loading zones. The short term plan for curb management policies will have a focus on safety for pick-up and drop-off locations for all vehicles including commercial, public transit, and TNCs.

This analysis serves as a baseline study for future comparisons of traffic crash analyses that may guide Iowa City's planning and safety actions. The intent of automated vehicles is to increase the safety of travel by drastically reducing the prevalence of traffic accidents that are classified as human-error. It may be many decades before fully-automated driverless vehicles are deployed. One five-year recommendation is to revisit the legal framework regarding double parking for two lanes in the same direction. Another recommendation is to incorporate a pick-up and drop-off management plan for the downtown. This plan defines safe pick-up and drop-off behavior, which includes set locations for temporary three- to five-minute parking for TNCs and 10-15 for commercial unloading. The intent is to adapt to the changes in travel behaviors to promote better health, safety and welfare for individuals who must pass through or who wish to enjoy the downtown area. As vehicles become more technologically advanced, it is anticipated that traffic crashes will be reduced due to sensing technologies and collision avoidance mechanisms. Until then, it is recommended to make small and feasible changes that may be useful in future advances in vehicle technologies.

SAFETY OF LOADING ZONES

Iowa City has had a number of loading zones and passenger loading zones marked by signs since 1994. They either prohibit parking to everyone except for commercial deliveries on some of the metered spaces from 2 AM to 6 AM, or allows certain time for free unloading from 8 AM to 5 PM, or both (Iowa City, 1994). Moreover, the City Code grants commercial vehicles to "stop, stand or park in a traveled lane while engaging in the loading or unloading of property" for 15 minutes both on one- and two-way streets in retail districts, given that enough space is left for the movement of traffic (Iowa City, 1994).

The team conducted multiple site observations, all suggesting that the peak for freight distribution occurs over the first half of the day. This coincides with the research on the topic, concluding that overnight deliveries require additional costs both for carriers and receivers, as it needs additional staff who work out of regular business hours, and thus can occur only if companies are offered

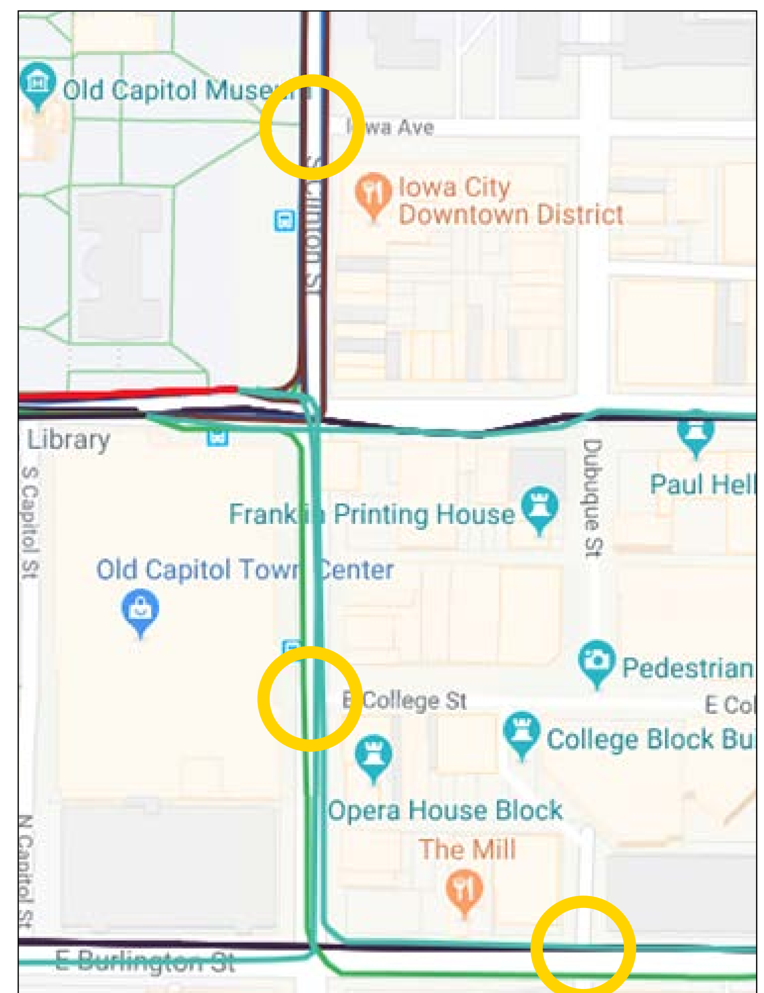


Figure 15: Frequent TNC stops downtown (Source: Authors)

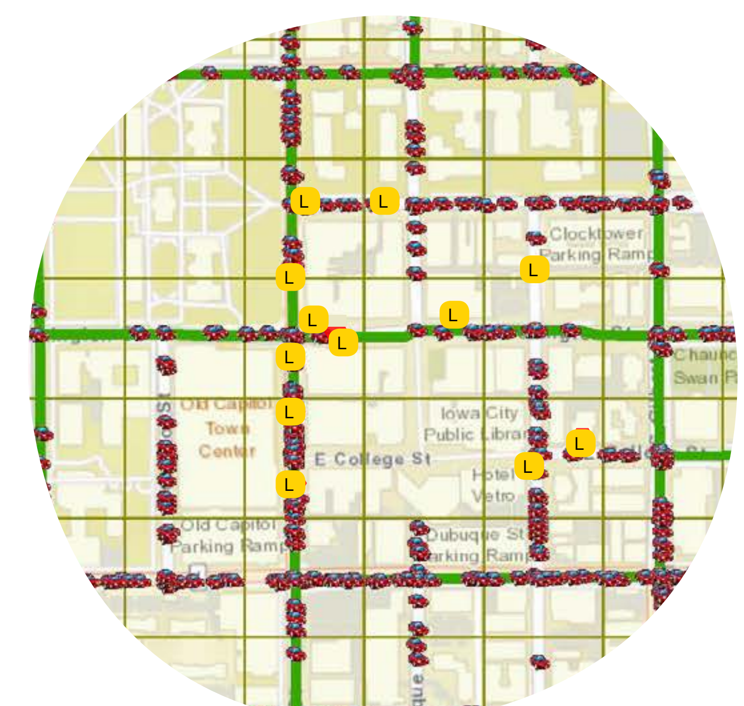


Figure 16: Loading zones and accidents (Source: Authors)

additional incentives for such effort (Labelle, 2016). Since multiple parking spaces that can accommodate a delivery truck are usually occupied during the day time, using the provisions in the City Code mentioned above, truck drivers are forced to double-park, often creating a whole additional lane of traffic. This creates a potentially dangerous situation, as loading zones are not only located on the busy streets with multimodal users, but also these are the places where numerous vehicular crashes take place.

On the other hand, we also observed the cases when commercial vehicles were parked next to the loading zones even if it was fully available. This ineffective use of loading zones adds to the finding of numerous parking violations in the areas of "Odd/Even parking" or "No parking" signs, that indicates a general lack of enforcement in the City.

SHARED MOBILITY & AV INTEGRATION

One of the strengths of Iowa City's transportation network is its conduciveness for the integration of shared mobility services. Supplementing the community's vision for a dense, walkable urban landscape with strong active transportation and transit linkages, the City's Complete Streets policy and long-range transportation plan provide the appropriate mechanisms for realizing this vision while the Climate Action Plan asserts several actionable transportation goals that can be achieved in the context of shared mobility modes. The existing shared mobility modes and the anticipation of the City's first bikeshare program serve as a critical starting point for identifying policy interventions the City can implement in order to address the current mobility challenges of residents while setting the appropriate stage for integrating AVs into the future transportation system.

However, untamed shared mobility modes could serve to exacerbate the current mobility challenges of Iowa City residents and create obstacles to the City's land use, transportation network, equity, and climate change goals. Specifically, expanded operations of transportation network companies, such as Uber and Lyft, could pose safety concerns, increase congestion and vehicle miles traveled, increase transportation emissions, and reduce transit usage. As such, Iowa City is urged to examine the impacts that shared modes exert on the transportation network and the effects these transportation options have on residents.

While Iowa City can be a leader in fostering shared mobility among smaller communities, several larger metropolitan areas in the U.S. have adopted policy measures and guides for developing shared mobility systems in their own transportation networks. For example, the City of Seattle adopted a New Mobility Playbook in 2017, while the Twin Cities and Los Angeles County have partnered with the Shared Use Mobility Center to develop the appropriate regulatory framework and policy interventions needed to formalize the consideration of shared modes in their respective transportation systems.

ENCOURAGE SHARED MOBILITY

The first step to encouraging shared mobility is to establish an appropriate regulatory framework for each shared mode. Existing literature has delineated three regulatory frameworks that can be used to guide policy interventions aimed at shared modes (Cohen & Shaheen, 2016). The approach of these regulatory frameworks ranges from maximum policy intervention to minimal policy intervention, and the selected approach should align with the policy goals of the City. Public engagement may provide additional insight toward an appropriate strategy. Public engagement throughout this process is important to develop an understanding about community sentiment regarding the regulatory strategies and implementations. Table 2 below presents the frameworks.

Shared Modes Benefit the Environment	Shared Modes are a Sustainable Business	Shared Modes are a Business
/maximum policy intervention/	/moderate policy intervention/	/minimal policy intervention/
Views shared modes as a public good	Views shared modes as services that offer social and environmental benefits	Views shared modes as profit-generating businesses
Shared modes play strategic role in reducing public costs of single occupant vehicles	Shared modes generate revenue and exert public costs	Allocation of public resources and support is formalized
Shared modes should be allocated public resources and public support	Shared modes should receive limited public resources and public support	

Table 2: Regulatory approaches (Source: Authors)

Based on the regulatory framework Iowa City chooses to adopt in addressing shared mobility modes, the City can then tailor specific policy recommendations consistent with the selected regulatory framework. The section below illustrates examples of policy interventions.

POLICY INTERVENTION SCENARIOS

For "Shared Modes Benefit the Environment"

1. Allocation of Public right of way: Iowa City should work with relevant stakeholders and the general public with regard to decision-making for formalizing the allocation of public right of way to shared mode operators:

a. Formal allocation of right of way: Require shared mode operators to apply for variances and/or special use permits for using public right of way; and

b. Informal allocation of right of way: Iowa City can adopt curb management policies that allocate public parking spaces and/or commercial loading zones on a case-by-case or non-binding resolution basis to shared mode operators.

2. Fees and Permitting for Shared Modes: Iowa City allocates public right of way at no charge to shared mode operators.

3. Signage and Installation: Iowa City pays for the cost of installing signage and right of way markings for shared mode operators.

4. Social and Environmental Impact Studies: Iowa City requires shared mode operators to author annual social and environmental impact studies related to their operations.

For "Shared Modes are a Sustainable Business":

1. Allocation of public right of way: Iowa City formalizes the allocation of public right of way by requiring shared mode operators to apply for right of way usage.

2. Fees and Permitting for Shared Modes: Iowa City assess fees and/or requires shared mode operators to obtain permits for operating in public right of way:

a. Fees assessed for on-street parking privileges and/or a fee per vehicle in operation; and

b. Iowa City can reduce fees for shared mode operators who operate in areas where residents have inadequate access to public transportation.

3. Signage and Installation: Iowa City requires shared mode operators to pay for required signage and markings; the city pays the cost of installation.

4. Social and Environmental Impact Studies: Iowa City requires shared mode operators to author annual social and environmental impact studies related to their operations.

For "Shared Modes are a Business":

1. Allocation of Public Right of Way: Iowa City codifies process for allocating public right of way to shared mode operators.

2. Fees and Permitting for Shared Modes: Shared mode operators must apply for permits to operate to offset foregone parking revenues and to defray administrative costs.

3. Signage and Installation: Iowa City requires all shared mode operators to pay for signage and markings, as well as the costs of installation.

4. Social and Environmental Impact Studies: Iowa City does not require social and environmental impact studies.

AV POLICY PROPOSAL: INTERVENTIONS FOR SHARED MOBILITY MODES

1. Implement a PUDO management plan in downtown Iowa City for regulating public right of way in the context of transportation network companies, paratransit operations, commercial operations in the short-term, and pave the ground for the management of automated vehicles operation in the future.

2. Create public-private partnerships to allow shared mobility modes to complement Iowa City transit:

a. Investigate the integration the BONGO app with shared mobility service providers to establish data repository that assists in understanding residential travel patterns.

b. Encourage shared mobility operators to enter into data-sharing agreements.

c. Encourage Transportation Network Companies to offer a mandated level of service in Iowa City's mobility-challenged areas.

POLICY INTERVENTION #1: PICK-UP & DROP-OFF MANAGEMENT PLAN FOR DOWNTOWN IOWA CITY

The development of private TNCs, such as Uber and Lyft, have revolutionized how people travel. With low-cost, on-demand service, and the proliferation of smart phones, TNCs allow residents to increase their mobility within Iowa City. Despite the benefits of TNC operations, there are certain challenges to these services. TNCs are not currently regulated in Iowa City and are free to operate anywhere in the City. This free reign can compromise the safety and efficiency of Iowa City's transportation network as TNC operators have no specific right of way for picking up or dropping off passengers, which frequently leads to double-parking and unsafe pick-ups and drop-offs. Furthermore, local traffic law allows for double-parking while on a road with two lanes traveling in the same direction. This in turn can pose safety risks to TNC operators and their passengers as well as increases in congestion. Once AVs are introduced in Iowa City roadways, these issues could be exacerbated as TNC vehicles with lower occupancy may be frequenting popular downtown destinations as they pick up and drop off passengers. Should these activities continue to be conducted without regulation, the adverse safety and efficiency concerns could be exacerbated.

Iowa City should therefore implement a strategy for regulating the operations of TNCs in the area most likely to experience the challenges brought forth by them—the downtown. With approximately 150 business owners and the core of the University of Iowa's facilities, the downtown is a popular site for dining, entertainment, and shopping. As such, there is a high level of demand for accessing these destinations. Collaboration with TNC operators should encourage the City of Iowa City to designate certain zones in the downtown area as dedicated pick-up and drop-off zones.

Actions for Implementing the TNC PUDO Plan:

• Flex Zones: Revise city code regulations for commercial loading zones that establishes these road spaces as Flex Zones that provide exclusive access for commercial loading and unloading during specified times and TNC passenger pick-ups and drop-offs during non-commercial load times. For example: commercial deliveries are allowed between the hours of 3 AM and 12 PM and TNC pick-up and drop-offs are permitted between the hours of 5 PM and 2 AM.

Considerations: Implementing Flex Zones will require city-led education among employees with diligent enforcement to ensure compliance; minimal public investment will be required for signage/markings; site shared mobility modes (i.e. bike share, scooter share, transit) within a 5-minute walk of Flex Zones; revise parking regulations after 6 PM in the downtown area to reflect pick-up/drop-off zones and limit non-TNC parking in them.

• Alternate PUDO Zones: Designate areas within a 5-minute walk of downtown area as PUDO zones where TNCs may pick up and drop off passengers at either all times of day or during mandated hours.

Considerations: Implement Alternate PUDO Zones on streets with less traffic; diligent enforcement to ensure compliance; minimal public investment required (signage/markings); site shared mobility modes within a 5-minute walk of Alternate PUDO Zones.

Enforcement: Enforcement of Flex Zones and Alternate PUDO Zones by the City is critical to their effectiveness. Iowa City is advised to enforce these zones through either the use of parking enforcement officers or utilizing traffic cameras that record violations of these zones. The associated costs of enforcement could be offset by requiring TNCs to pay fees and/or permits to operate in the City.

Outcomes of Implementing the PUDO Plan

• Orderly and efficient use of downtown right of way; and

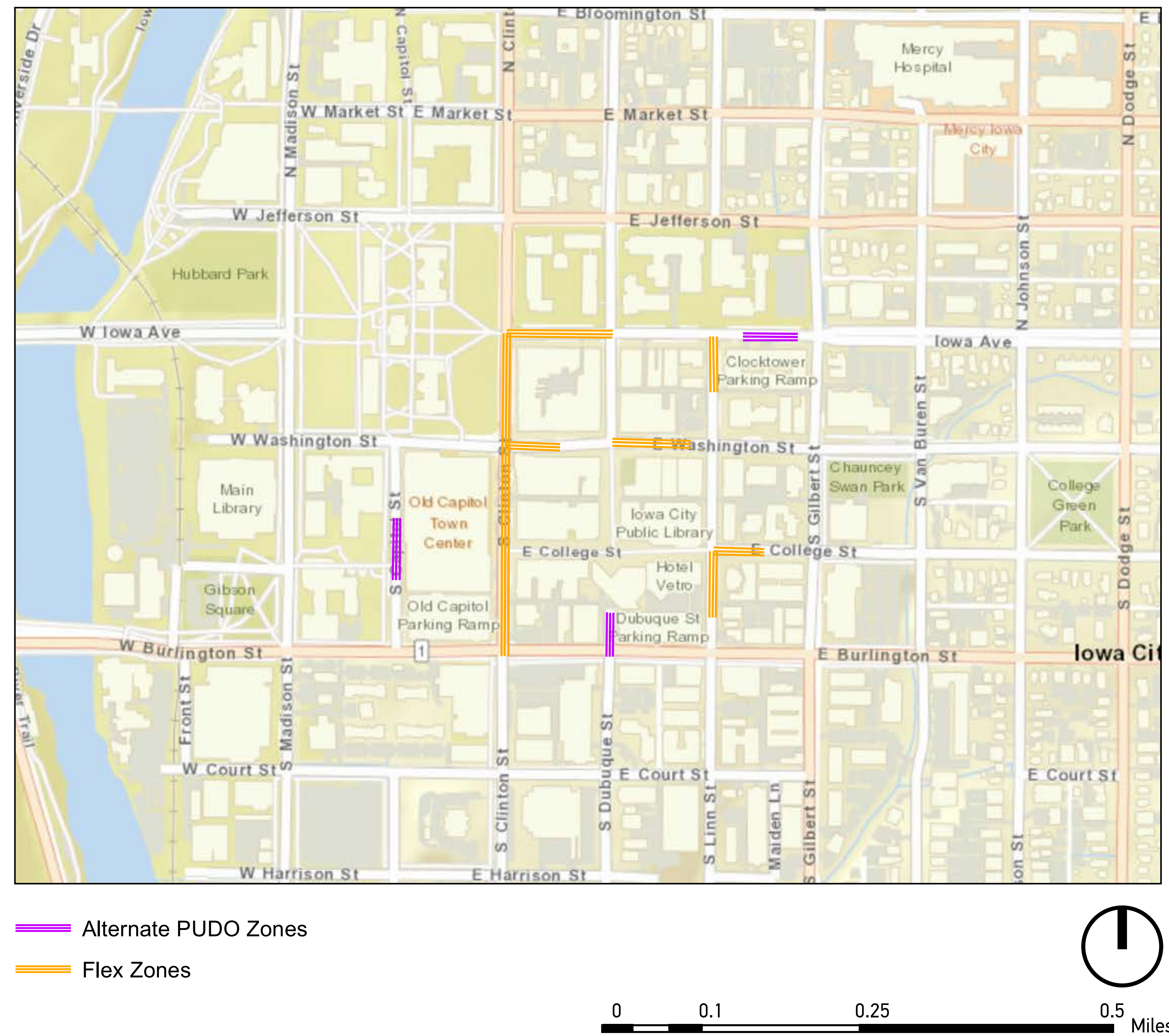


Figure 17: Proposed Flex Zones and Alternate PUDO Zones for Downtown Iowa City (Source: Authors)

• Improved safety for TNC operators, passengers, and other road users.

Measures of Success in Implementing the PUDO Plan

• Establish a baseline for analyzing safety benefits of the PUDO Plan by utilizing TNC and city crash data for a baseline time period prior to implementation of PUDO for comparison of future time periods.

POLICY INTERVENTION #2: CREATE PUBLIC-PRIVATE PARTNERSHIPS

Public-private partnerships (P3) have recently gained the attention of various state and local governmental entities as federal funding for transportation projects has seen a declining trend due to various reasons (Maltin, 2019). These partnerships leverage the innovative nature of the private market to assist in funding projects that have mutual benefits for both the private and public stakeholders involved. As Iowa City advances toward a future in which shared modes, and potentially, AVs, could play a greater role in addressing the mobility challenges of residents, City officials could look toward public-private partnerships to assist in the funding and monitoring of the programs that aim to guide Iowa City toward a more efficient and equitable transportation system.

Within the context of the Iowa City transportation system, shared mobility service providers could enter into data-sharing agreements with the City government so that City leaders and shared mobility service providers can better understand residential usage of these transportation options, ensure equitable access for all residents, and improve the safety of residents through the identification of specific areas in the city where infrastructure improvements are necessary. As of now, several options exist for Iowa City to pursue in creating a data repository that has the ability to track data related to the following: parking verification, fares for using the service, utilization of shared mobility fleet vehicles, and trip start and end data, i.e. the time and location of trips taken in Iowa City. Currently, Uber maintains Uber Movement, which is a data repository that the company uses to help planners and policy makers develop data-informed decisions related to transportation planning projects (Gilbertson, 2017). Additionally, the Los Angeles Department of Transportation has developed a data repository to manage shared mobility service providers through the Github platform, which is a public data repository that allows for the LA DOT to track, in real time, data related to shared mobility usage amongst residents.

Actions for Implementing Shared Mobility Public-Private Partnerships in Iowa City:

• Leverage the Bus-on-the-Go (BONGO) app: Create a digital platform that links transit users with shared modes by encouraging shared mobility service providers to establish a data repository that can assist City leaders in understanding residential travel patterns and inform residents of alternative transportation modes.
• Encourage shared mobility operators to enter into data-sharing agreements: Allow the City to formalize and regulate the operations of shared mobility service providers in the City's transportation system so the impacts of these providers can be better managed through data-informed analysis as TNCs currently do not share data with local governments due to protections of proprietary information. Through creating a regulatory environment that encourages data-sharing with the City, TNCs could be incentivized to share data, such as trip origin/destination, average length of trips, average number of fleet vehicles in service, etc., that can be used by the City to analyze and regulate TNC operations.

Community	Policy	Description
Fort Lauderdale, FL	Passenger Loading Zones for TNCs/Taxis	A city-wide ordinance that established "Passenger Loading Zones" for specified hours during the day; authorizes TNCs and taxis to park in these zones for a maximum of 5-minutes while picking up passengers
Washington D.C.	Nightlife Parking Demonstration	A pilot program located in the DuPont Circle neighborhood that delineates 4 street segments dedicated to passenger loading for TNCs and taxis during the hours of 10 PM on Thursday night through 7 AM on Sunday mornings
San Francisco, CA	Color Curbs Program	An update to the local loading zones regulations that allocated colored curbs for commuter shuttle loading purposes, and identifies the potential for these colored curbs to be used by TNCs in the future

Table 3: PUDO Zones in Other U.S. Communities (Source: Authors)

City	Regulation	Description
Boston, MA	Uber Data Sharing Agreement	Uber will provide the city of Boston with data related to the date and time, area of origin, distance traveled, and duration of each trip taken via the operator
New York, NY	Licensing and Regulation of For-Hire Transportation Services	The city of New York passed legislation that requires for-hire transportation services to share data related to date and time, total mileage, and fare for each trip taken as well as the amount of time each vehicle is in service per day
Oakland, CA	Equity Carshare Policies and Practice	The city of Oakland requires carsharing service providers to share data related to VMT, vehicle GHG emissions per mile, safety records, average customer fares, and number of users and vehicles with the city.

Table 4: Data Sharing Agreements for Shared Mobility Service Providers in Other U.S. Communities (Source: Authors)

• Encourage Transportation Network Companies to offer a mandated level of service in Iowa City's mobility-challenged areas: As part of the data-sharing agreement, Iowa City could require TNCs to offer a mandated level of service for the communities disadvantaged residents by utilizing geo-fencing technologies that create a virtual boundary in which TNC service is prohibited outside of and to ensure an adequate number of vehicles are located in the areas of the City that could benefit from them the most.

• TNC service providers can opt out of fees and/or be granted an expedited permitting process for voluntarily entering a data-sharing agreement.

Outcomes of Implementing Shared Mobility Public-Private Partnerships in Iowa City:

• City officials and decision-makers can make data-informed decisions regarding the regulation of shared mobility service providers and management of public rights of way.
• Increase equitable access to alternative transportation modes for all residents through identifying "need areas" in which mobility-challenged residents reside and targeting shared mobility services in these areas.
• Identify street and infrastructure design improvements in specific areas of Iowa City to increase pedestrian and automobile user safety in the public right of way.
• Increase mobility options for mobility-challenged residents by ensuring access to TNCs in disadvantaged neighborhoods.

Measures of Success in Implementing Shared Mobility Data-Sharing Agreements:

• The Bus-on-the-Go (BONGO) app is expanded to include locations of shared mobility modes for transit users.
• Regulation of shared mobility service providers is formalized in the Iowa City code.
• All existing shared mobility service providers have entered data-sharing agreements with the Iowa City, and all prospective service providers are permitted to operate contingent upon their entrance into a data-sharing agreement.
• A data repository is created that the City and shared mobility service providers may utilize it to monitor travel conducted via shared modes.
• Integration of geo-fencing technologies to ensure consistent service to mobility-challenged neighborhoods.

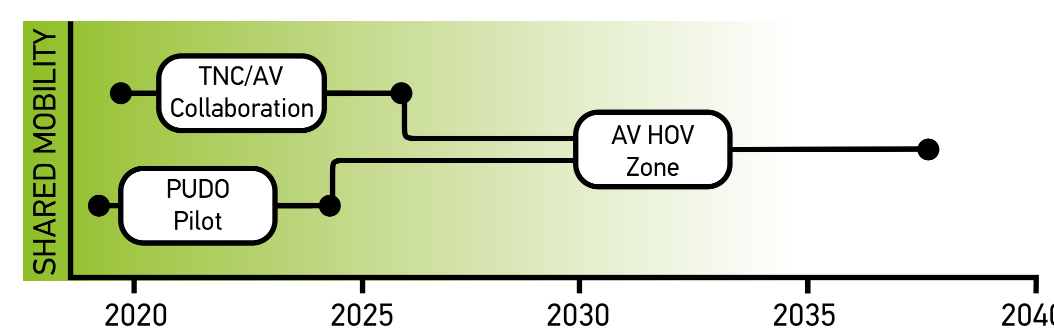


Figure 18: Shared mobility recommendations timeline (Source: Authors)

STRENGTHENED TRANSIT

Automated vehicle technology is on its way to becoming a major transportation mode that will occupy future roads. Researchers anticipate that this technology will decrease auto ownership rates and increase auto usage frequencies of United States' residents (Brandon & Michael, 2017). There is a potential for AVs to be deployed as publicly shared fleets (Shared Automated Vehicles or SAV), and if this scenario takes place, households might be able to reduce their car ownership rates by half. Currently, people's demand for a second or a third car increases with income. However, this ownership trend could change the future of transportation should an increasing number of shared automated vehicles operate on public roads. Abandoning the second and third car will relieve household financial burdens, as on average, car ownership costs $9,000 annually in the U.S. (Stepp, 2018).

However, unlike shared or personally owned AVs, existing public transit systems cannot give door-to-door service, which is one of the major limitations of the current system in Iowa City; the inability to offer on-demand service in a cost-effective manner exerts a substantial impact on transit ridership rates. In this new era of emerging transportation technologies, the transit system should be modernized. SAVs can introduce a new form of public transit - defined by characteristics of low capacity and high accessibility - with the vehicle being capable of choosing the optimum route for delivering passengers to multiple destinations. Public transit agencies may see cost reductions as there will likely no longer be a need to hire drivers to operate transit vehicles; a second cost-saving measure public transit agencies may expect to capitalize on is the electrification of the transit fleet, and thus the currently high fuel costs will be reduced. Driverless small van options may cater to the requirements of numerous household trips that cannot be fulfilled by the households first car or primary transportation mode. Presently, the majority of Iowa City households fulfill those demands by owning a second or third car. Additionally, ride-hailing service costs are expected to decrease significantly due to electric propulsion capabilities and full AV technology; this reduction in cost may make the operation of a mid-sized shared automated vehicle economically viable. Research suggests that private ride-hailing services will be inexpensive in the near future as they will be totally driverless, and thus will incur lower operating costs due to decreased labor needs. Therefore, Iowa City should consider using these emerging technologies and transportation options to improve its current transit system and better serve its residents.

SCOPE OF THE TRANSIT STUDY

The focus of this segment of the study was to assess alternative public transit service opportunities that can better serve low-income neighborhoods, night shift workers, and high-income neighborhoods as to help them eliminate the need for a second or third car. The detailed methodology of the analysis is described in the appendices section (A.1 Transit study methodology).

An automated mid-size van option with door-to-door transit capabilities will be evaluated in the long-term plan for the transit system. Additionally, an analysis of a shared voucher program for accessing private ride hailing services was evaluated in the short-term transit improvement plan for the City. Furthermore, the determination of the impact of these options on achieving transportation equity was performed in both the short- and in long-term recommendations. The outcomes from this analysis will be helpful for Iowa City's future transit improvement study and may serve as a guideline for other cities interested in the prospect of automated vehicle technology in supplementing their transit systems.

TRANSIT SYSTEM IN IOWA CITY

The Iowa City Transit system developed in the 1910s when the first electric railway was built in Iowa City. By the early 1970s, Iowa City had developed a bus transit system whose routes were planned with the consideration of equal service between all geographical areas of the City. Since the initial transit route study was conducted, the city has expanded and the population has increased. Iowa City Transit Authority has adapted to the dynamic landscape of the city by modifying their route system to provide transit accessibility to all residents. Due to these actions by the City, difficulty exists regarding the equitable access of the transit system across the City. Currently, 23 city bus routes are in operation, as displayed in Figure 21. The population of the City is increasing, and the City is expanding by annexing land from the periphery for both single and multifamily housing developments; this expansion has prompted the city to plan transit expansions to serve these new developments. The current transit system operates from 6:30 AM to 10:00 PM on weekdays, with lower frequency of services after 6:30 PM. While some lower frequency routes operate on Saturdays, there is no Sunday service available. Iowa City transit also provides services to supermarkets such as Walmart and Aldi during both weekdays and Saturdays. The City transit service is complimented by the University of Iowa CAMBUS service, established in 1972 by the students at the university.

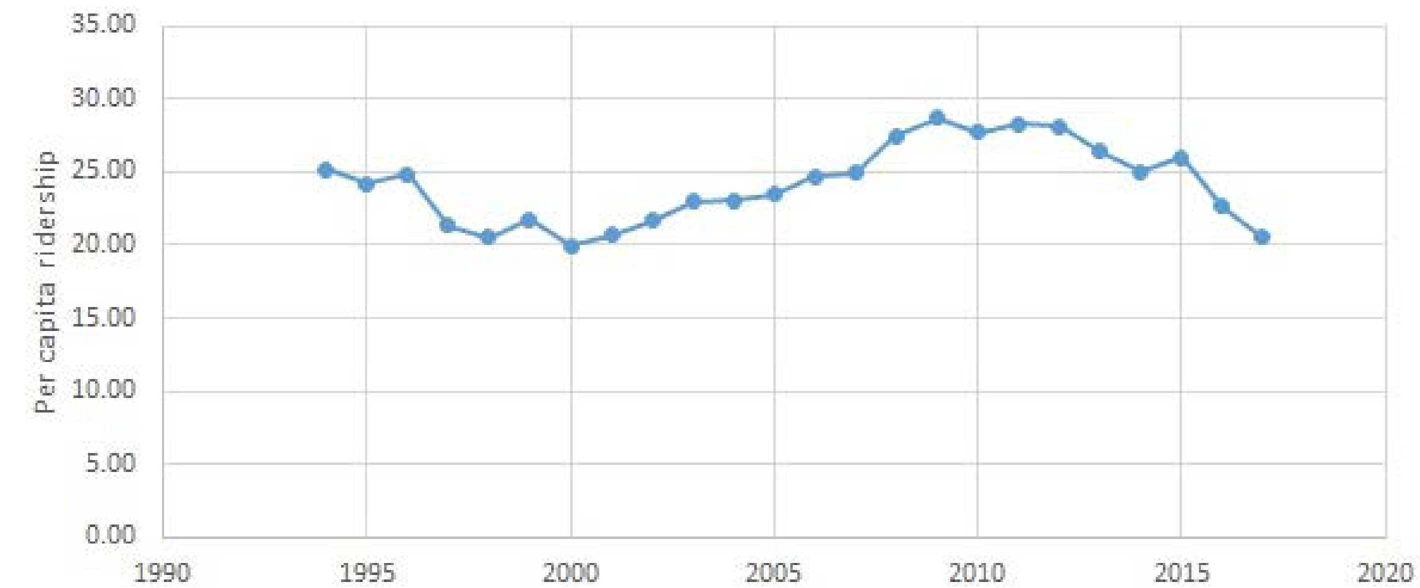


Figure 19: Per capita ridership on Iowa City Transit, 1994-2017 (Source: Authors)

TRANSIT RIDERSHIP

Iowa City's transit system currently provides an average of 15,068 trips per day while ACS 2016 data estimates that nearly 10% of Iowa City residents use transit for their work commutes. Compared to other similar-sized communities in Iowa and across the U.S., Iowa City ranks high on transit usage. However, recent data on transit ridership for the Iowa City transit system shows that annual ridership has been declining. This data, collected from the Johnson County Metropolitan Planning Organization Transit Performance Report, looks at ridership levels from the years 1994 to 2017 and offers insight into transit usage patterns for the City. Figure 19 and Figure 20 illustrate these trends graphically.

As Figures 19 & 20 illustrate, ridership on Iowa City Transit systems was roughly steady from 1994 to 2005; however, after 2005, it experienced a rapid increase in their ridership until 2009. In 2010, it experienced a decrease in ridership compared to the previous year. Interestingly after 2010, ridership on Iowa City transit experienced a steady increase until 2012, where the transit system saw ridership levels begin to plummet. After 2015, the transit system experienced another drastic decline in ridership compared to previous years. Also, the decline is notable in that the 2017 ridership level is actually back down to the 1994 ridership level despite an increase in population.

Should ridership levels on Iowa City transit see further declines, the implications for mobility challenged residents could persist, and even increase. Declining revenues collected by the transit authority could result in reduced service levels and the discontinuation of certain routes, again impacting riders who have limited alternatives for commuting and traveling in the City. With the introduction of automated vehicles and greater proliferation of shared mobility services and TNCs, Iowa City transit may no lon-

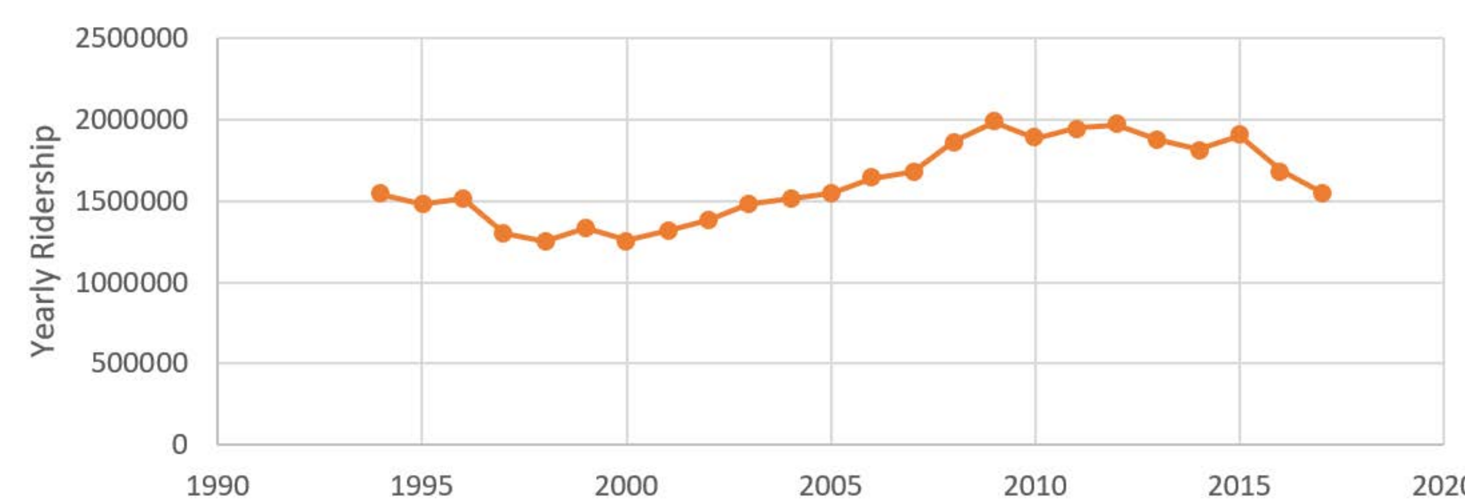


Figure 20: Annual ridership on Iowa City Transit, 1994-2017 (Source: Authors)

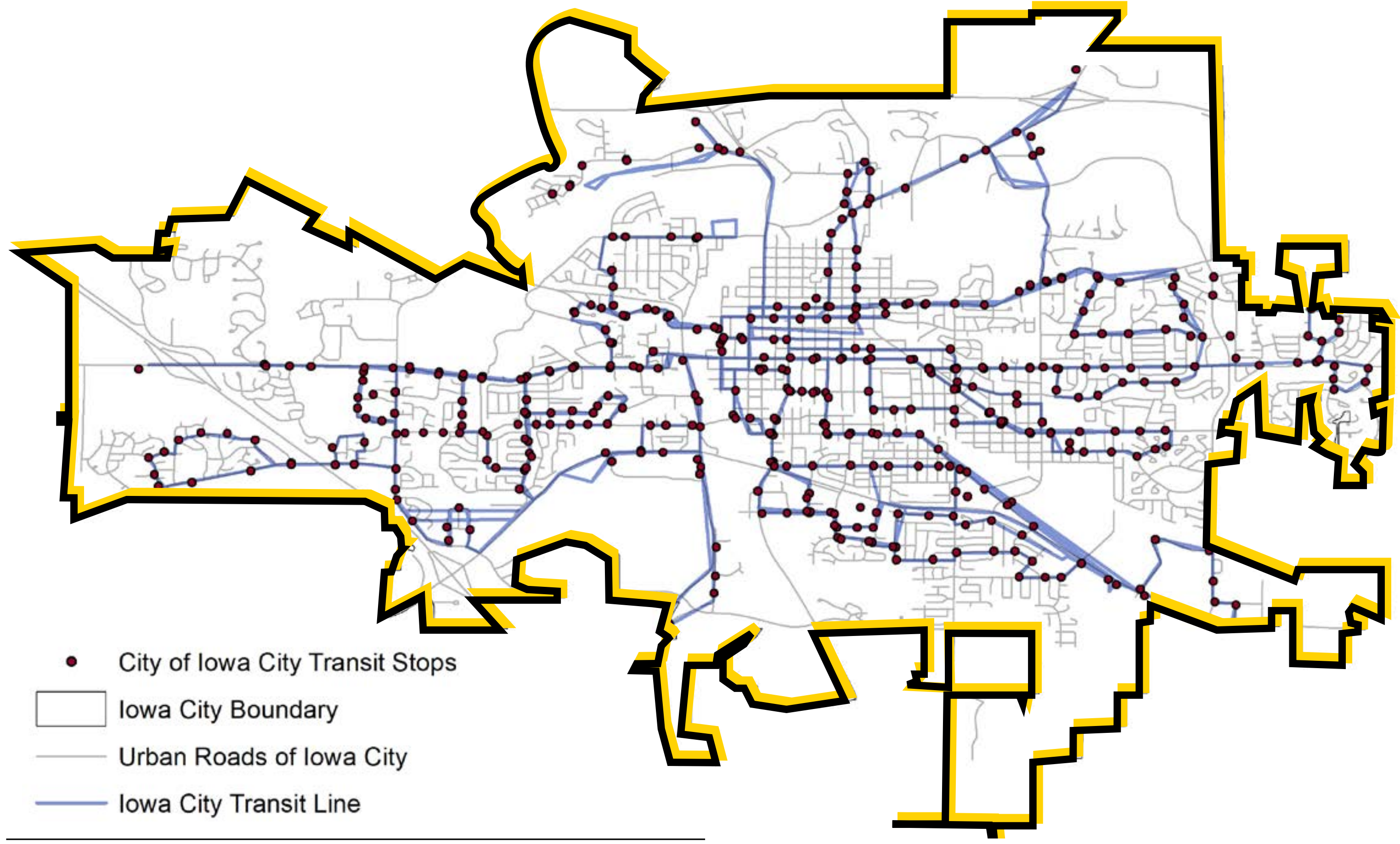


Figure 21: Operational Transit Routes (Source: Authors)

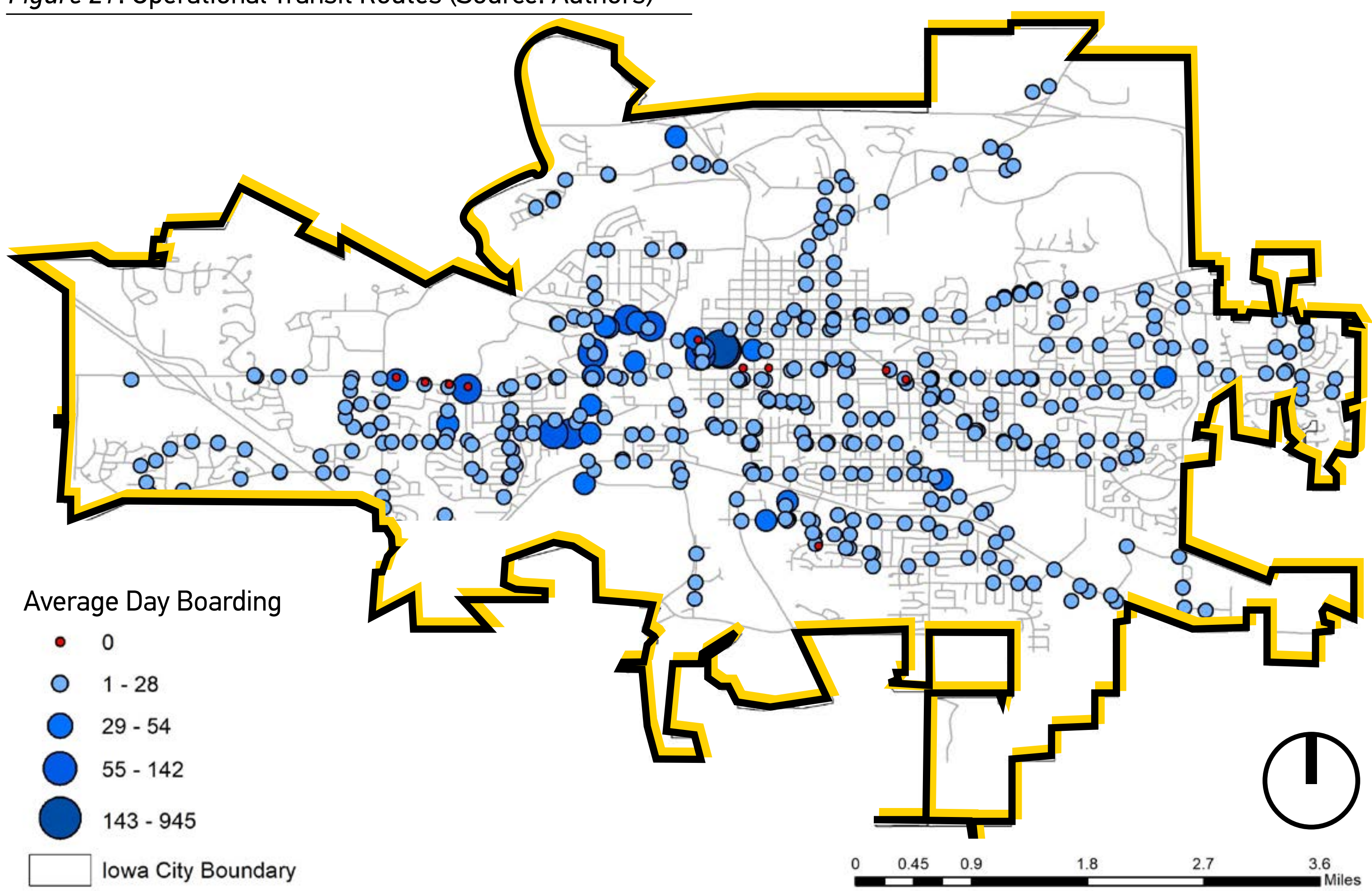


Figure 22: Transit boarding at different stops of Iowa City (Source: Authors)

ger be able to compete with these transportation options. As such, the planning team envisions a future transit system in which Iowa City transit integrates automated vehicle technology into the system through small, neighborhood AV shuttles that offer door-to-door service for residents; these neighborhood shuttles then connect users with fixed-route trunk lines that efficiently move residents across the City to their destinations. Not only could this future transit system allow Iowa City to operate an efficient and equitable transit operation that serves all residents, it could serve connections to shared mobility services and other alternative transportation options while discouraging the use of private vehicles and aid Iowa City in maintaining its pedestrian-friendly environment.

TRANSIT SERVICE & USE

The City has previously conducted a two-week long transit boarding count for all the stops served by Iowa City transit. The study found significantly lower demand at a large number of stops. In this section the average daily transit boarding data were mapped to illustrate the level of transit usage in the different areas of Iowa City. Figure 22 shows the average daily boarding at all stops served by the City, which were calculated from the two-week sample counts. It can be observed that a significant portion of the stops showed zero boarding throughout the survey period; these stops are represented by red dots in Figure 22.

Additionally, it is also necessary to analyze the frequency of the transit system with reference to this boarding data. The analysis of the transit frequency was done using the per day stop frequency of each bus, measured by the number of times in a day a bus serves that specific stop. This analysis illustrates that some of the areas of Iowa City are underserved by the transit system (Figure 23). It can be clearly seen that transit service is highly concentrated in the central part of Iowa City and is very limited outside the core area of the City. It should be taken into consideration that the City's population is increasing, and a significant portion of the student population and low-income households reside in those neighborhoods outside the City core.

The planning team observed significantly low boarding in the periphery area of the City. To better understand the relationship between transit boarding and transit frequency for each stop, the team performed a correlation analysis. A correlation value of 0.54 was calculated; this value assesses the relationship between demand, as measured by the average number of weekday ridership per stop, and supply, as measured by the daily service frequency to that stop. A correlation value of 0.54 indicates a moderate association between transit usage and provision of service. As this demand data was collected from the two-week survey of the City Transit Service, the variation in the observation is high. Therefore, a longer period ridership data is necessary to validate this point and reveal the actual relationship between transit demand and supply.

The analysis also found low service frequency in the low-income areas of the City. This was found by overlaying the stop wise transit service frequency data into the block group data showing the population living below the poverty line. It was observed that outside of the central area of the City, outlying block groups are not adequately served by transit, especially in locations where significant proportions of low-income households reside. This is illustrated in Figure 24.

TRANSIT ACCESSIBILITY

The analysis of accessibility is an important concern in any transit study and several methodologies exist for performing these types of analysis. This study used transit stop location data to assess transit service area and accessibility. For calculating the transit service area, a 0.25-mile buffer was applied to each individual transit stop. The rationale behind the use of this buffer is rooted in the consensus among researchers that an individual will walk a maximum of 0.25 miles to access transit service. However, barriers to accessibility may exist if people within the 0.25-mile radius are not able to access that transit stop due to a lack of pedestrian infrastructure in the associated service area. To evaluate resident accessibility to Iowa City transit stops, the planning team, with the help of the ArcGIS Network analyst tool, built a road dataset for the City of Iowa City and performed a service area analysis for the transit system as presented in Figure 25 (for detailed methodology see A.1 Transit study methodology). The calculated initial service area was 8.53 square miles. It can be seen from the map that a significant portion of the City's roads are not accessed by the current transit system in consideration of the 0.25-mile walking distance to the stops.

Also, overlapping the transit service area with the residential area of the Iowa City shows 75% of the residential area is accessed by the transit system. Additionally, 79% of the business and commercial area, 57% of the institutional, and 69% of the industrial land uses are currently covered by the transit service area.

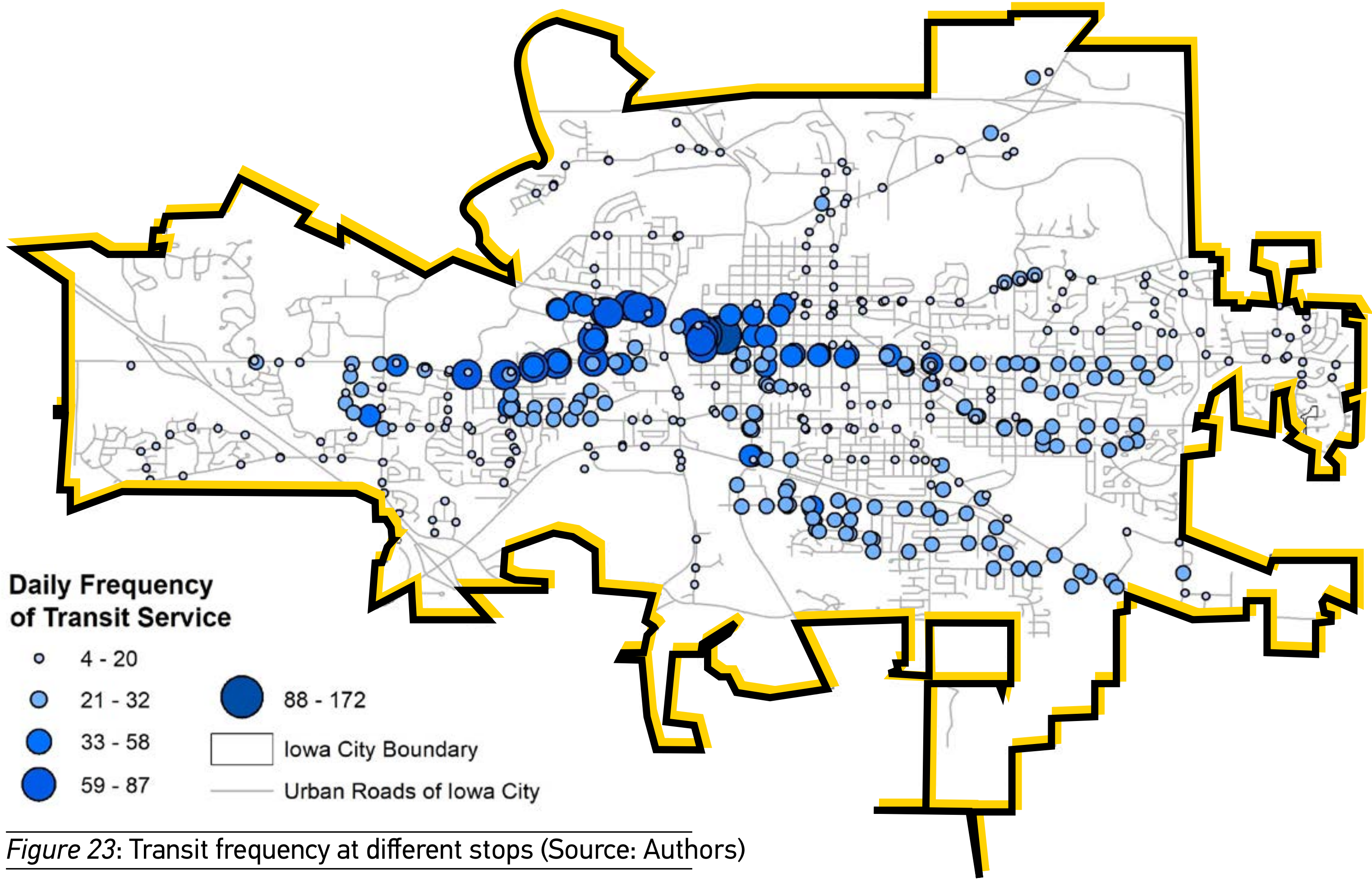


Figure 23: Transit frequency at different stops (Source: Authors)

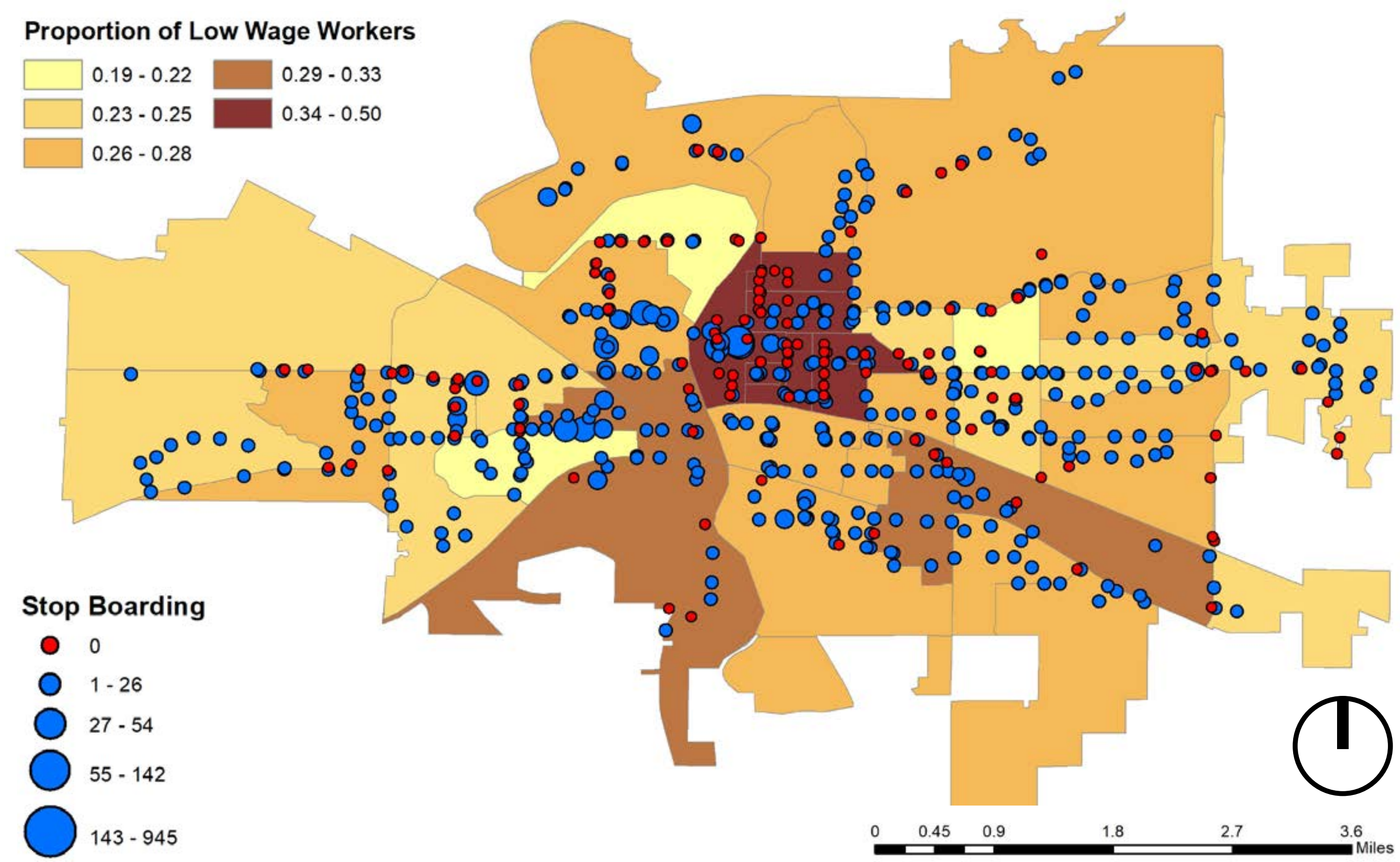


Figure 24: Transit Service and low-income population (Source: Authors)

TRANSIT USE IN WORKING TRIPS

Work commutes are an important set of trips made on the Iowa City road network and these trips are facilitated using a variety of modes. There are certain benefits of utilizing the transit system for commuting purposes such as reduced parking demand and fewer vehicle emissions. Therefore, data on the portion of commuting trips made by workers may supplement future transit planning efforts. For this reason, a map showing the percentage of residents using the transit system for their commuting trips was prepared by the planning team. Block group level ACS data was used to show the transit usage in different areas of Iowa City. Figure 26 shows the percentage of commute trips made using transit in each block group. One concern is that this data does not correlate well with the boarding data of the City, shown in Figure 22. The boarding data shows significantly low levels of boarding in neighborhoods outside the downtown area. One of the reasons for this can be attributed to the low population density seen in the outlying neighborhoods of Iowa City, which could mean that boarding is significantly low due to the lower concentration of residents in these areas. On the other hand, boarding levels for the central area of the City could be inflated due the high population density paired with a small portion of the population that uses transit and thus result in an artificially high boarding level for the area. One limitation to this map is that it only accounts for the working trips of residents while other types of trips are not considered.

It can be seen from Figure 26 that workers from several outlying block groups of Iowa City use transit service frequently for their work trips. It was also observed that when comparing this map with the low-income population distribution of the City, most of those block groups have a higher percentage of low-income people. Therefore, it is implied that a significant portion of low-income use transit service for their work trips.

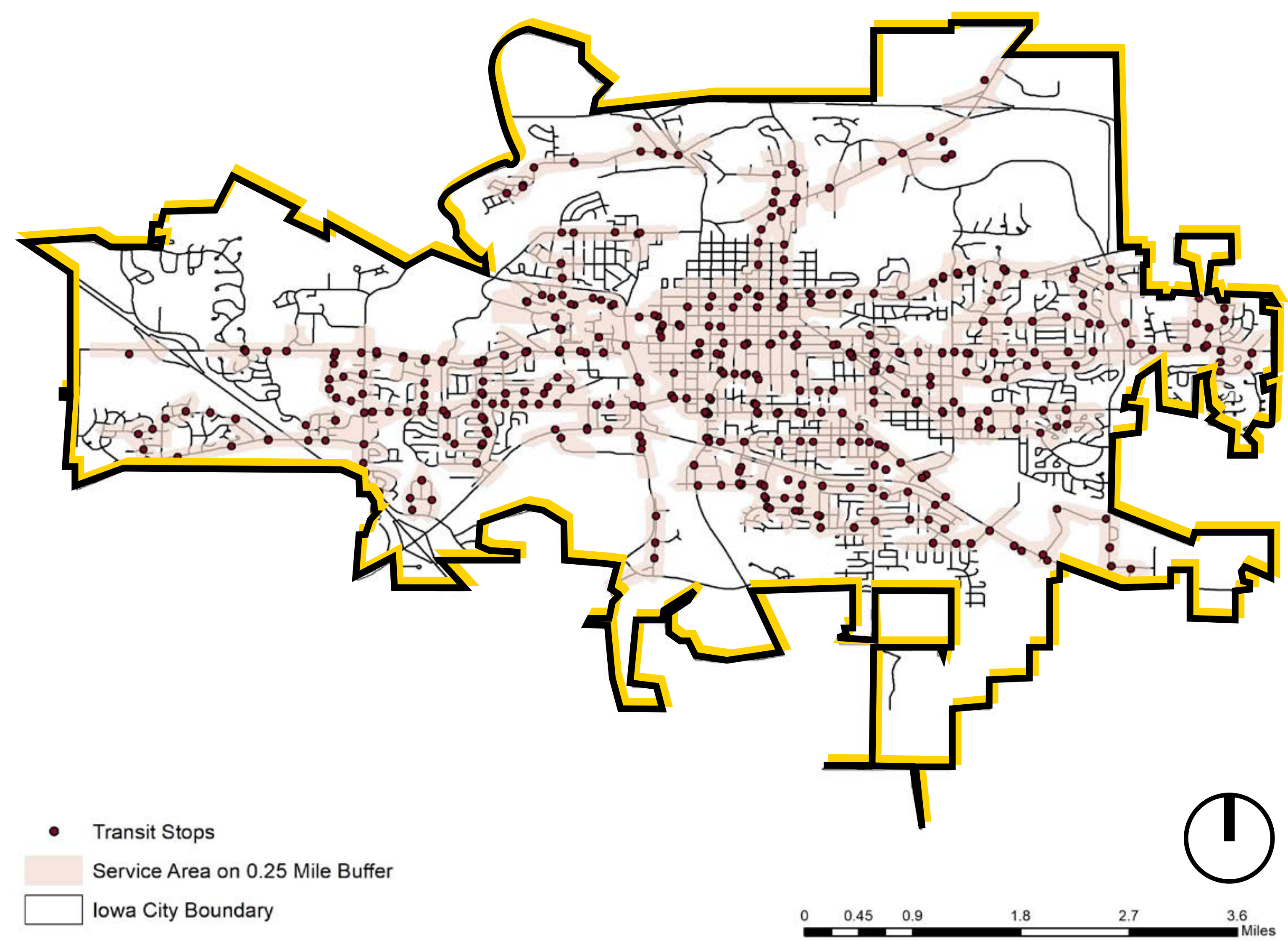


Figure 25: Iowa City Transit service area using 0.25 miles radius around stops (Source: Authors)

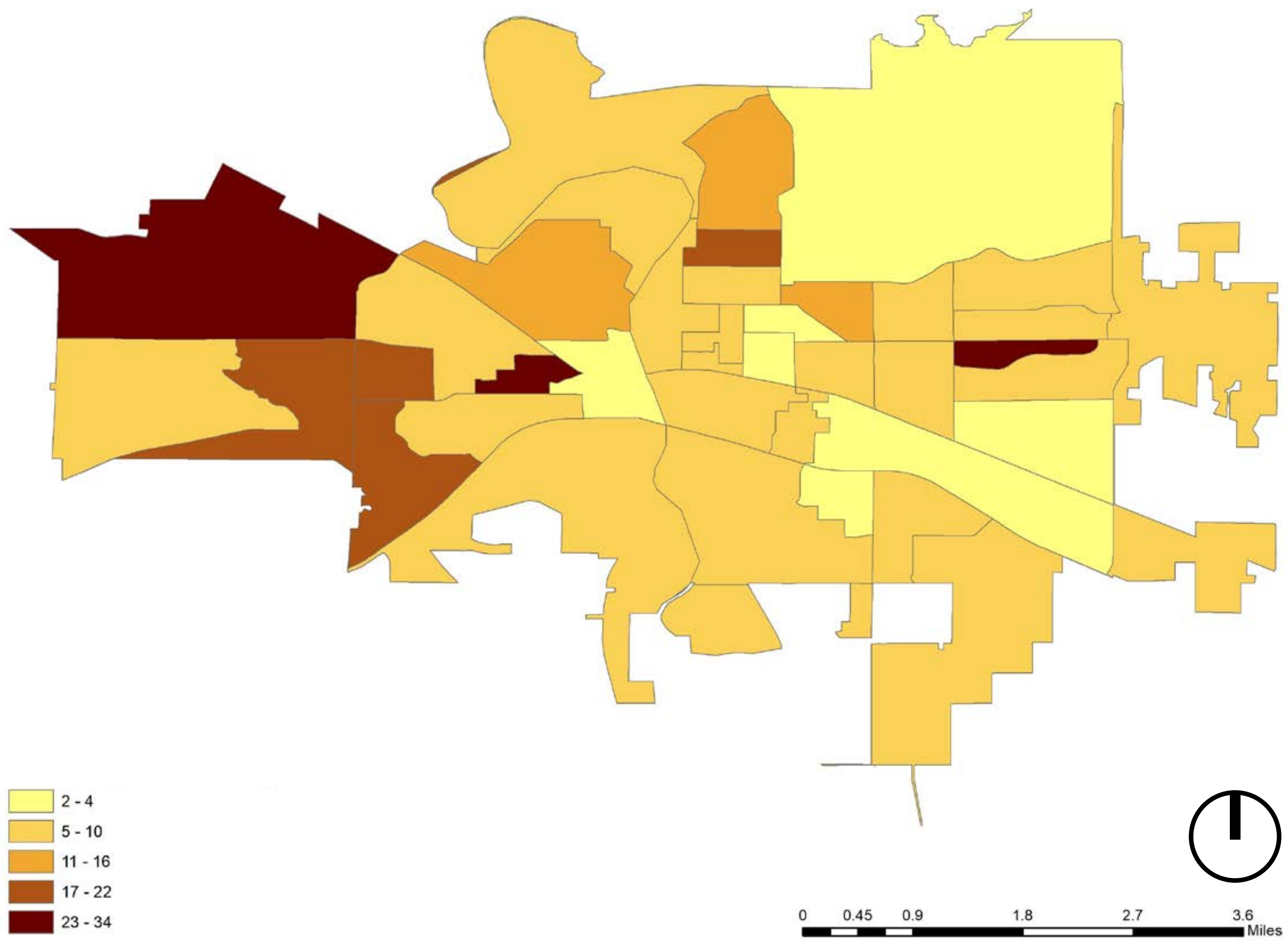


Figure 26: Percentage of workers using bus in their work trips by block group (Source: Authors)

EXISTING COST OF TRANSIT

The cost of providing transit service in Iowa City is relatively low compared to other midsized communities in the U.S. Based on data from both the City of Iowa City and Johnson County Metropolitan Planning Organization Transit Performance Report, the revenue per vehicle mile was calculated. For the calculation of the cost of providing transit service for each route, the length of each bus route was calculated using ArcMap and then multiplied across the estimated cost of providing one trip. Data from Johnson County Metropolitan Planning Organization Transit Performance Report found that in Iowa City, the operational cost of transit service per revenue vehicle mile is $6.93. However, the riders per revenue vehicle mile was recorded as $2.2, which is very low relative to other midsized communities in the U.S. (Johnson County MPO, 2018). It was found that the City provides a transit subsidy of $4.73 for each mile of operation, which is a significant expenditure for the City to incur but a substantial portion of this subsidy is funded by grants from the Federal Transit Administration (FTA). Table 5 displays the current lengths and operating costs of each of Iowa City's transit routes. The estimated cost per passenger trip was calculated by dividing the estimated cost per route trip by the average number of passengers the route served in a trip. This average number of passengers served per route trip was calculated by the 2 weeks boarding sample data set of the City.

Figure 27 illustrates the cost to boarding ratios for the different Iowa City transit routes. It should be noted that some of the routes serve a significant number of stops that record low boarding levels, which leads to additional operating costs per trip incurred by the transit service. However, it was observed that service in lower-income neighborhoods, such as Oakcrest, Westwinds, and Plaen View, has been very efficient due to low per trip costs. Furthermore, it was found that night services are highly efficient on these routes, indicating a high demand for daytime transit service on these specified routes.

Transit efficiency is a growing concern for any city. As

Routes	Route length (miles)	Cost of a route trip ($)	Cost per trip ($)
Oakcrest	5.11	35.4	1.20
Oakcrest Night	6.26	43.36	1.42
Westwinds	6.4	44.37	1.73
Plaen View	6.46	44.78	1.88
Town Crest	5.84	40.45	2.16
Westwinds Night	6.7	46.42	2.30
Court Hill	5.87	40.71	2.59
Broadway	5.94	41.15	2.72
7th Avenue	5.11	35.42	2.77
Lakeside	8.47	58.71	2.92
Mall	9.09	63.03	3.11

Routes	Route length (miles)	Cost of a route trip ($)	Cost per trip ($)
Rochester	7.02	48.65	3.28
Westport Plaza	7.59	52.57	3.42
Towncrest Night	6.2	42.94	3.51
Cross Park	5.27	36.5	3.65
Westside Hospital	11.86	82.19	3.78
North Dodge	7.71	53.45	5.16
Manville Heights	10.47	72.53	5.97
Broadway Night	10.12	70.14	5.97
Eastside Express	9.61	66.63	6.61
Melrose Express	8.26	57.22	7.15
North Dodge Night	10.83	75.07	7.77

Table 5: City routes cost of operation (Source: Authors)

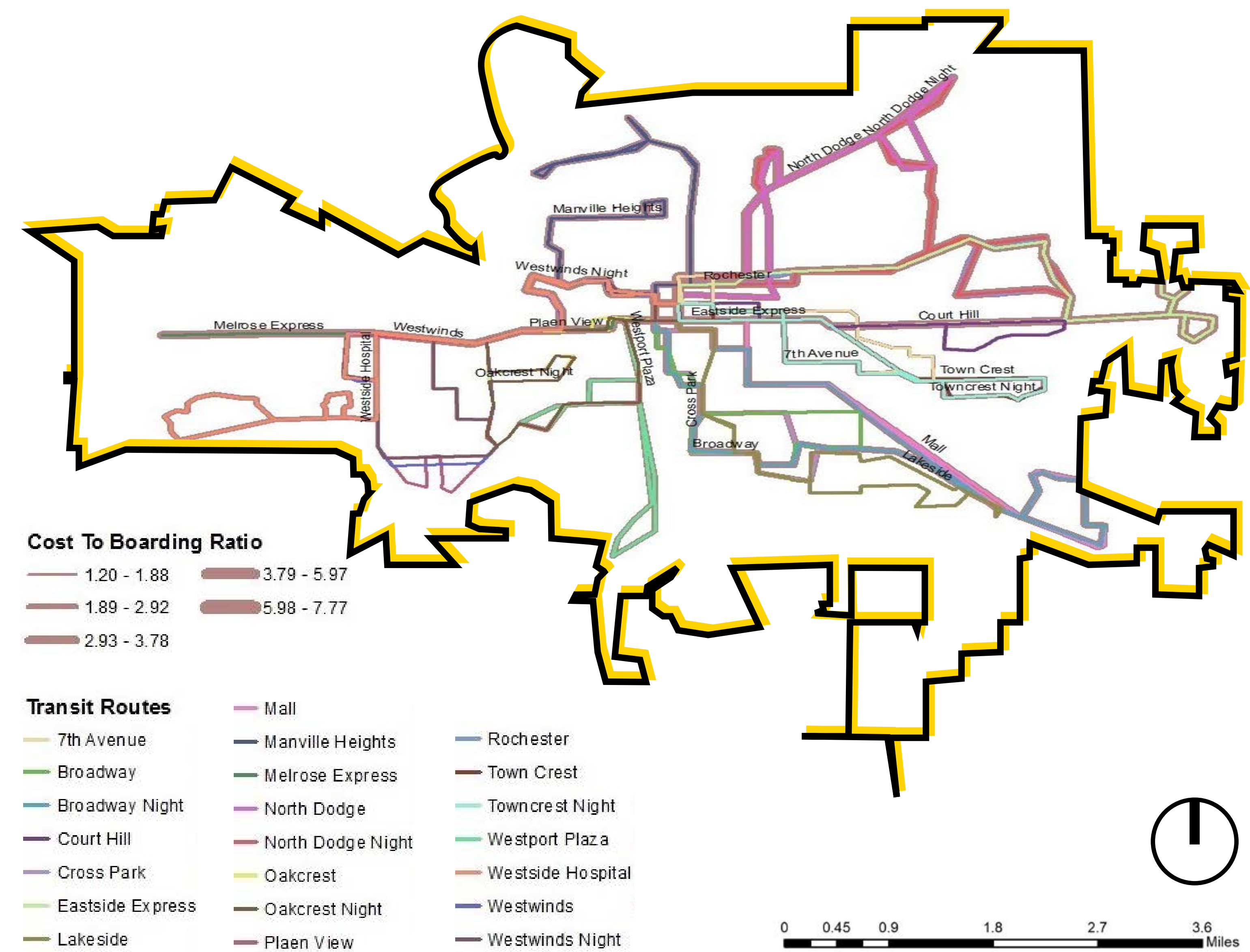


Figure 27: Transit operational costs (Source: Authors)

can be seen from the previous analysis, transit demand is significantly lower in certain areas of Iowa City. The implication here is that the proper reconsideration of those area's service frequency is critical for improving transit efficiency. However, the consideration of the efficiency of the transit system must also incorporate equity measures to improve residential access to the transit operations in Iowa City. Simple options to pursue the maximization of the efficiency of the transit system include a reduction of frequency or a completely halting of services in these low-demand areas. However, this decision will not be without substantial political and equity implications. Nevertheless, the introduction of AVs can offer potential cost-effective alternatives to the current transit services.

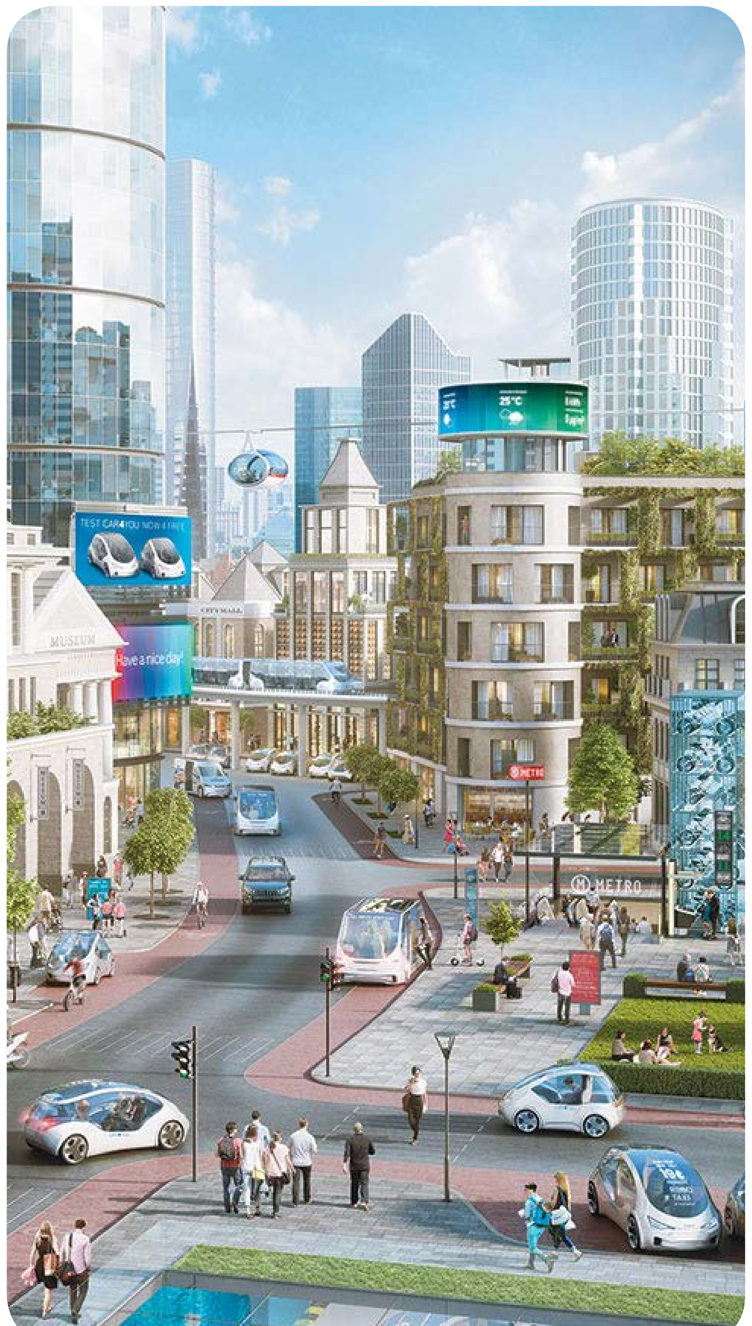


Figure 28: A scenario of AV deployment (Source: Bosch)

AV POLICY PROPOSAL: INTEGRATION OF TRANSIT & AV

In order to make transit competitive in the era of automated transportation and emerging ride-hailing services, the long-term vision of this plan incorporates a value proposition for the Iowa City transit system so as to illustrate the potential benefits that could accrue to transit users. This value proposition summarizes why an individual is incentivized to use transit in the event of wide availability of private AVs and inexpensive ride-hailing services. These incentives for transit users will help the transit authority develop a competitive service relative to other competing modes of transportation. The value proposition proposes a basic system framework for Iowa City Transit to consider in the near term. The essence of this framework is captured in the following statement:

"Iowa City Transit provides high frequency transit services through the use of automated shuttles, which are integrated with bike sharing and other active transportation infrastructure, and includes door-to-door, on demand transit services all day and every day, while emphasizing service to employment centers, commercial centers, and supermarket locations".

Offering door-to-door, on demand service would require a significant increase in the service area of Iowa City transit. In order to achieve this significant expansion while addressing the first and last mile issue of transit, automated driverless community shuttles could be incorporated into the current transit system. These AV shuttles could provide Iowa City with more reliable service at lower operating costs and provide an opportunity to revive declining transit ridership levels.

AV EXPANDS TRANSIT SERVICE

To inform the design of the AV shuttle program in Iowa City, a literature review was done to identify the critical aspects owing to a successful AV shuttle system. One study that looked at the incorporation of automated vehicles into a public transit system found that these vehicles can expand transit service areas from 0.25 miles to 2 miles (Lu, Du, Jones, Park, & Crittenden, 2017). An additional study explored the use of an automated community transit network that was integrated with the existing transit system to resolve transit accessibility gaps within within that transit system (Levine, Zellner, Shiftan, Alarcon, & Diffenderfer, 2013). Based on the considerations highlighted by these two studies and the use of a 2-mile buffer around transit stops, a future service area for Iowa City Transit was determined. In this new scenario, the transit service area expanded to 15.68 square miles. It was also found that the fixed route buses were serving approximately 167 miles; with the introduction of the automated community transit vehicles, the potential service length expands to 243 miles of both major thoroughfares and minor roads not currently served by the transit system. These lengths were calculated using the select by location tool of the ArcMap and data sourced from the urban road database. In conclusion, this analysis has found that significant improvements are possible through the incorporation of automated vehicles in the City transit system and these improvements can bring service to the doorstep of residents. Therefore, the introduction of low-speed automated shuttles can provide ample service to all of Iowa City's neighborhoods.

The vision crafted by the planning team consists of a future transit system that offers all residents a flexible, on-demand service that efficiently moves transit riders to their destinations. Leveraging evolving transportation technologies, such as AV, could assist Iowa City transit in realizing significant cost savings, and in turn, allow the transit authority to expand the current service area and provide an inexpensive transportation option for all residents regardless of where they live in the City.

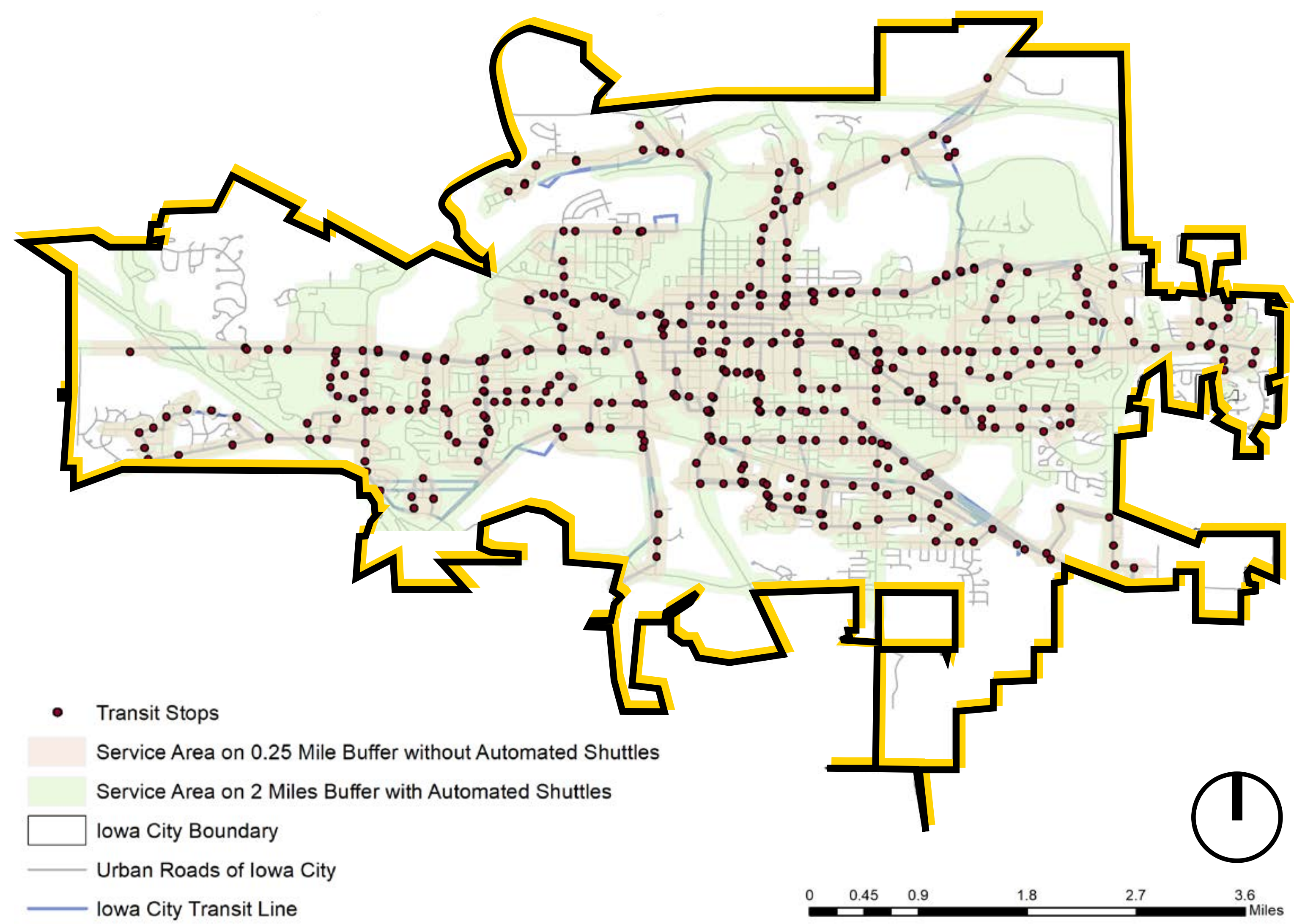


Figure 29: Current Iowa City Transit service area with/without AV (Source: Authors)

The service proposed by the planning team consists of two components:

1. Several large AV buses serving as trunk lines, moving larger volumes of riders across the City along fixed-routes with fewer stops.

2. A series of smaller AV shuttles, offering on demand, door-to-door and door-to-trunk line service in Iowa City neighborhoods.

General Characteristics of the Fixed-Route AV Transit Service:

- Larger AV buses with capacities comparable to traditional transit buses.
- "Trunk-line system" connecting neighborhood shuttles to key employment and commercial hubs.
- Limited stops along routes.
- Headways of no greater than 15 minutes.
- Higher priorities given for routes serving low-income neighborhoods and neighborhoods which have a high number of zero-car families to increase service for mobility challenged households.

General Characteristics of the Neighborhood AV Shuttles:

- Small AV shuttles with capacities of 10-12 passengers.
- "Feeder system" collecting passengers in Iowa City neighborhoods and connecting them with the fixed-route AV lines.
- Door-to-door service with transit users ordering shuttle pickups on-demand.
- Services offered 24 hours a day, 7 days a week.
- Shuttle service to supermarkets and food retail destinations.
- Shuttle services connect to shared mobility services to offer residents alternative transportation options for completing trips.

Outcomes of the Future Transit System:

Through envisioning a future transit system that integrates AVs to offer residents an on-demand, door-to-door mobility service that connects them to fixed-route lines serving employment and commercial hubs, Iowa City could see a future in which transit ridership increases while trips made in private vehicles decrease. Below are the main potential outcomes of the transit system envisioned by the planning team:

- Door-to-door, on-demand AV shuttle service could replace the short-term voucher services run by the City (See voucher section of the short-term plan).
- 24-hour door-to-door services could offer residents, especially those with mobility challenges, increased opportunities to travel to grocery stores and other destinations for daily goods while reducing dependence on private automobiles.
- New transit stops sited adjacent to shared mobility services, offering residents a wider variety of transportation options.
- 24-hour high frequency service could help the City meet the commuting demands of residents while helping the transit system attract new users and potentially encourage further declines in private vehicle usage.

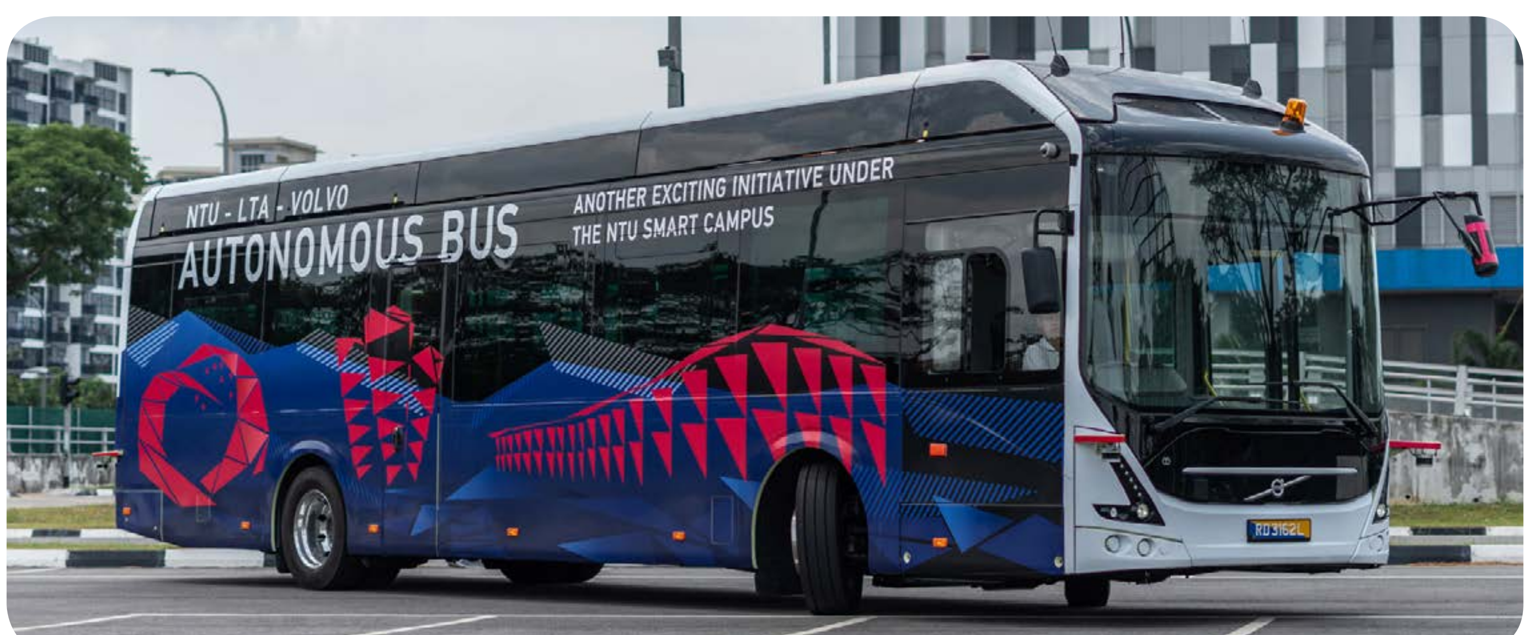


Figure 30: A large automated bus by Volvo in Singapore (Source: Dezeen)

Figure 31: A small automated shuttle by NAVYA in Neuhausen am Rheinfall (Source: Swisstransitlab)

AV CONSIDERATIONS FOR IOWA CITY

While the potential benefits afforded by this future transit system are numerous, there are several considerations that Iowa City Transit are advised to address. First, this on-demand service will serve residents door-to-door and will operate on neighborhood roads. Due to the potential for increased road usage in Iowa City neighborhoods, the capacity of the neighborhood roads should be evaluated to accommodate the safe movement of the small transit shuttles. A second consideration related to this is the need for Iowa City leaders to take a role in engaging community members about the potential operation of AV shuttles in their neighborhoods. Recent media publications extensively detail the current climate around residential approval of AV pilot programs operating in various communities across the U.S. and overall, the operations of AVs are not well received as indicated by these poor vehicles being the target of rock throwing and attempts made to run them off the roads by other road users. Through maintaining an open and transparent channel of communication with residents regarding their desire for the role AVs could play in Iowa City's transportation system, City leaders can be in a better position to effectively plan for this technology and deliver outcomes that benefit all residents. A final consideration for the future transit system is the employment losses related to the operations of AV shuttles. This unfortunate circumstance that is likely to occur with the proposed integration of AV technology in the transit system would almost certainly result in the Iowa City transit authority no longer needing transit operators. However, these AV shuttles will still require on-board attendants and individuals to maintain the fleets, so the employment losses are not entirely absolute. The implications of this final consideration mean that City leaders and transit officials should prepare for a frank conversation regarding the future need of transit operators and to begin planning for this circumstance.

AV SHUTTLE PILOT

As time moves forward, information about AVs tests and pilots becomes less surprising, and rather ubiquitous, the better understanding of potential implications of its deployment emerges. Rigorous models and analysis take the place of anecdotal evidence and advertising campaigns, bringing a better understanding of the critical power public policy holds over the scenario that will take place, and whether AV technology will become a boon or the bane of our cities. Given that, a sound course toward shared automated vehicles should be established by the City of Iowa City, to ensure the increase in access, equity and sustainability with the deployment of new technology.

Integration of shared automated shuttles into the Iowa City transit system should be gradual, leaving room for

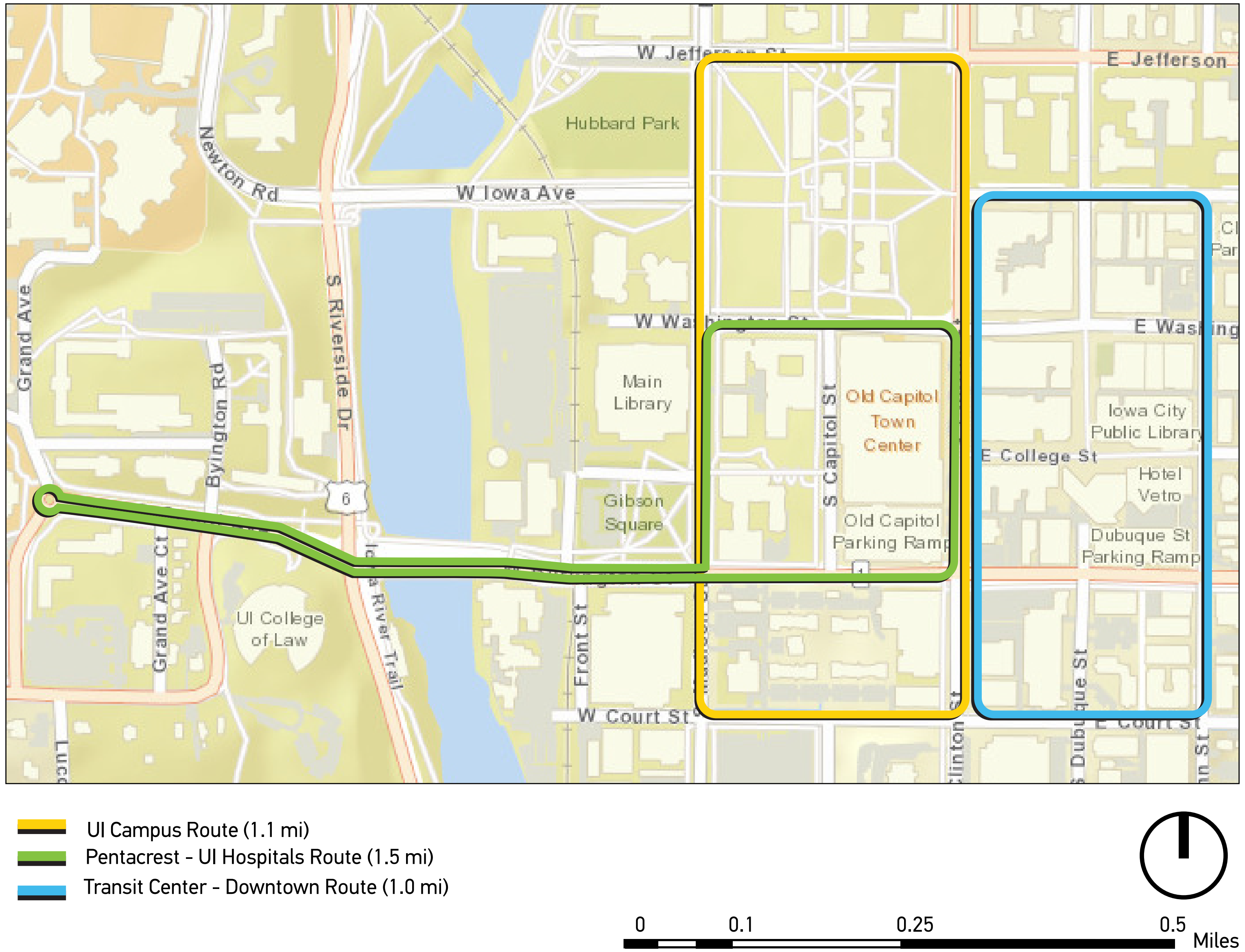


Figure 32: AV downtown shuttle pilot potential routes (Source: Authors)

technology to ripen and become cheaper, while the City adapts through trial and error on a small scale. The first pilot should be deployed in the highest transit ridership area – downtown Iowa City (see Figure 22), to allow the maximum public exposure to shared AVs, test riders' perceptions, behavior, actual propensity to use and to incorporate their feedback in the next phases. The team recommends the next step of new service tests addresses the low transit frequency in areas with a larger share of low-income residents (See Figure 24). After the analysis of the two pilots and incorporation of lessons learned through their operation, there should be fewer technical and public impediments for initiation of a full-scale network of shared on-demand AVs.

Both the existing research discussed in previous sections and stakeholders' interviews conducted by the team suggest there is a general propensity toward fast adoption of private AVs once they prove to be reliable enough. However, models developed for larger U.S. urban areas bring evidence that the rapid increase in the number of vehicles (even though they will be automated) can only exacerbate the congestion and from 6 to 12 times decrease accessibility to jobs for low-income residents. On the other hand, the rise of trip pooling and improvements of transit systems due to the integration of new technologies more than doubles the access to opportunities in the region (Ezike et al., 2019). While the level of service on Iowa City's roads creates very little impediment to the flow of traffic now, it is expected that by 2045 congestion might reach levels that require expansion of existing infrastructure (Johnson County MPO, 2012), even without private AVs roaming the streets.

Currently, mass media and the public pay very little attention to shared and mass transit AVs (McMahon, 2018), though there are communities that explore such opportunities through pilot projects, like Rochester, MN,

Ann Arbor, MI and Chamblee, GA, with the first two being actual tests, and the last one highlighting a community effort to prepare for the deployment of a shared AV shuttle. Each case had its own specific goals, focusing either on vehicle operation in specific conditions of the region and infrastructure measures that are to be developed, integration of automated technology and transit to improve service, establishment of collaboration between the public and private sector, education of public and its feedback (WSB & Associates, Inc. and AECOM, 2018), research of human interaction and confidence in new technology (Mcity Headquarters, 2018), or contribution to the community's vision, economic, transportation and environmental goals (Stantec, 2018).

Since the proposed pilot project can not satisfy all the criteria mentioned above in one effort, the team recommends the city to focus on the following in the initial phase of the pilot:

Figure 33: Examples of AV shuttle signage (Source: Mcity)

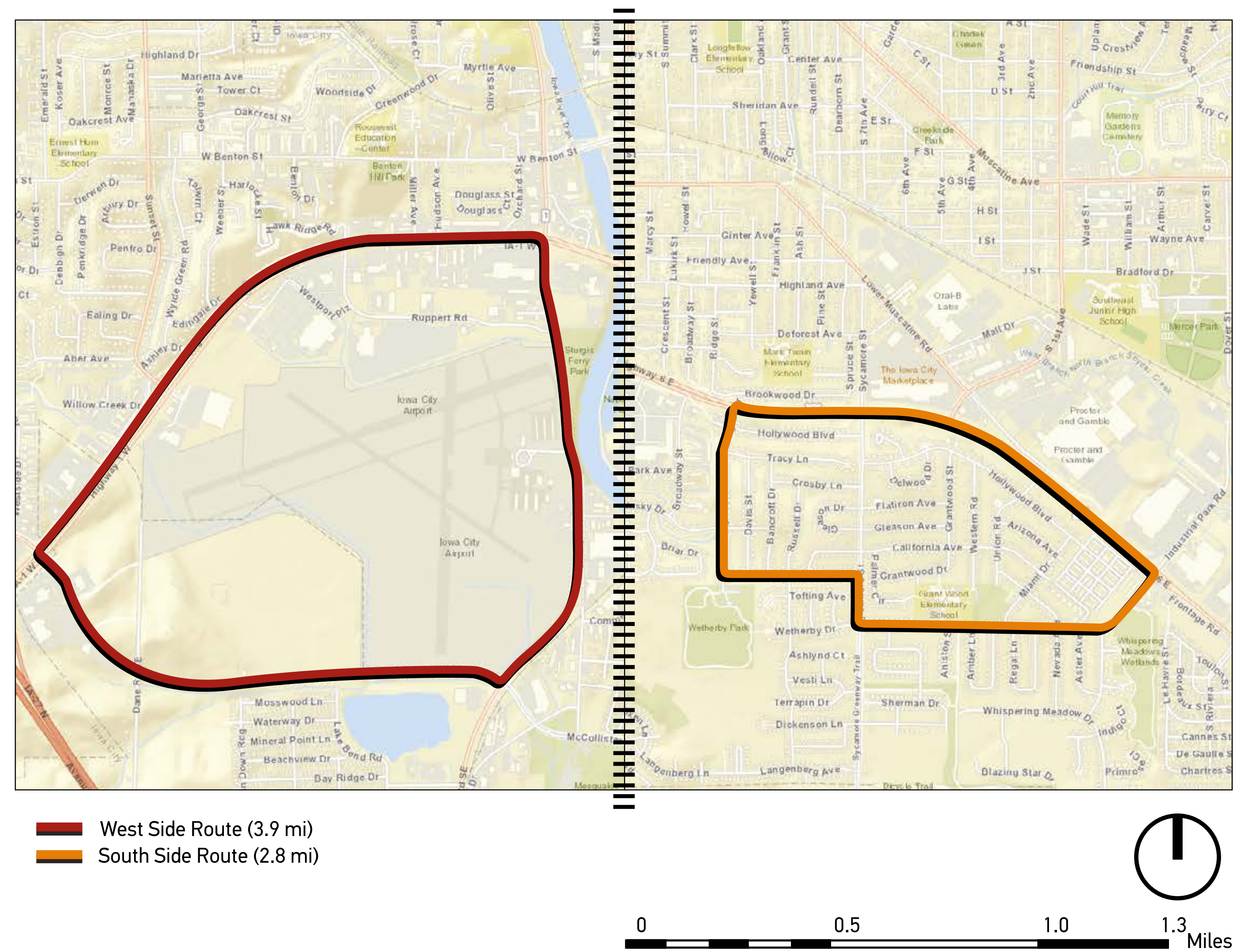


Figure 34: AV district shuttle pilot potential routes (Source: Authors)

• Education of the public on the benefits of shared AVs and an assessment of perception.
• Development of a public-private collaboration model in the provision of transportation services.
• Identification of necessary infrastructural improvements that allow safe operation of shared automated vehicles.

The prevailing approach to AV shuttle tests in U.S. cities is the collaboration between either state departments of transportation or major research institutions with a private company that leases a small fleet of 11-seat vehicles for a period ranging from a month to a year. Examples of such partnerships can also be found in Gainesville, FL, Columbus, OH, Las Vegas, NV, Detroit, MI, San Ramon, CA, and Arlington, TX, and they also provide guidance towards the provisions that test routes should have:

• Route length is generally limited to approximately 1 mile, depending on the specificity of the built environment, on roads with a mix of various modes of transportation, but without heavy traffic and with no more than 10% of road incline.
• Specific signage must be provided along the route and on stops.
• Advanced mapping of the road and training of drivers who can take over the operation in unconventional cases should precede the actual deployment of vehicles.
• Vehicle storage and charging facility must be close to the route.

Since the technology at its current stage cannot be left without human supervision, all AV shuttles used for public testing require the presence of an operator, who can take over the control in cases of unpredicted events. In the University of Michigan pilot that role is extended to ensuring the safety and quality of user experience, and with the title of safety conductors, those people encourage riders to participate in surveys and are an onboard source of information about the shuttle. (Mcity Headquarters, 2018). This also contributes to the positive image of a shared AV, as such position is a potential employment for bus drivers in the future.

With the objective of public exposure to the benefits of shared AV shuttles, the team developed three routes for the potential first stage of the pilot (Figure 32). The premise of the green route is to connect the downtown campus of the University of Iowa with the University Hospitals. The yellow route connects facilities with high pedestrian traffic like the University of Iowa Recreational Center, the University of Iowa Main Library, Iowa Memorial Union and Iowa City downtown. The blue route aims to connect the regional 380 Express bus with Iowa City's downtown.

The second stage route proposals are aimed to bridge the gap in frequency of transit service for low-income neighborhoods next to Iowa City Municipal airport or the Southeast Side of the City and effectively utilize automated vehicle technology to address the equity concerns in the community.

Given the state of knowledge and best practices analyzed by the team, it is believed such pilot tests are a proactive and timely measure toward the improvement of the City transportation system and such experience is essential for the continuous competitiveness of public transit. Nevertheless, this recommendation is envisioned as a first step toward such activity, as consultations with the public, officials and stakeholders on the finalized routes, time and aspects of operation are yet to be conducted.

INTERIM MEASURE: VOUCHER PROGRAM

Automated shuttles with 24-hour services is one of the key options to address the current deficiency of the transit system. Nevertheless, the immediate wide-scale use of this technology is not possible due to the technological barrier. Therefore, a voucher program is proposed to serve people's mobility needs who currently are not served by the limited schedule of the transit services (6:30 AM to 10:00 PM). The voucher service will address the transportation equity issue and reduce the cost burden of the mobility disadvantaged population. Due to the current state of AVs, it will be difficult to introduce automated transit within the next five years. Because of this limitation, the planning team designed a voucher program to serve residents who are not currently served by the transit system. The team conducted a cost estimation for providing low-income residents with ride vouchers for local TNCs, such as Uber and Lyft, with the goal of specifically serving those residents who work off-hours and weekends. This voucher option can help those residents who face mobility challenges and assist disadvantaged households in lowering their transportation expenditures; a successful voucher program can assist the City in achieving its goal of transportation equity.

Residents eligible for the voucher program will be able to use them between the hours of 9:00 PM to 6:30 AM, which is the period when the transit service is not in operation. Another criteria of the voucher program is that residents are able to use them a maximum of five times per week. After performing the calculation based on the specified metrics, it was found that number of residents eligible for the voucher program in Iowa City is 1,067, with a cost to the city of $26,675 per week in providing

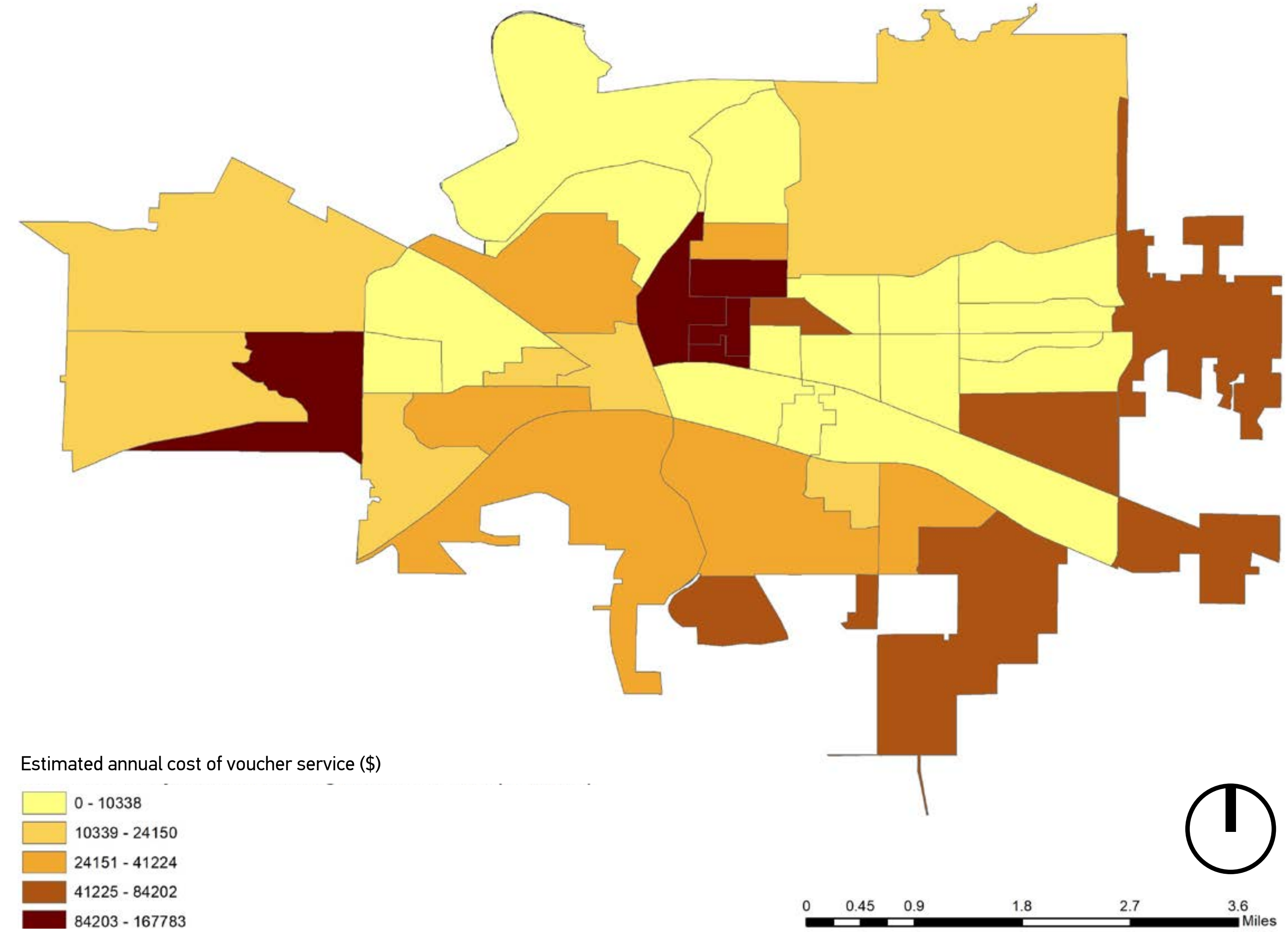


Figure 35: Cost of voucher for off-time workers provision by block group (Source: Authors)

the vouchers. In terms of annual cost of the provision of the voucher program, the city can expect to pay $1.39 million (See A2. Voucher program calculation appendix section for more detail calculations). Figure 35 breaks down the annual cost per block group of providing the voucher. Nevertheless, this value is an estimation; for an accurate calculation of the true cost of providing the voucher program to residents, a detailed origin-destination survey will need to be conducted by the City to better understand the demand for a program like this. The voucher program can help the City to achieve its goal of providing transportation accessibility for all segments of the population, with special consideration of people with fewer mobility options. Figure 36 outlines the timelines of all the possible measures regarding incorporation of AVs in the public transit of Iowa City.

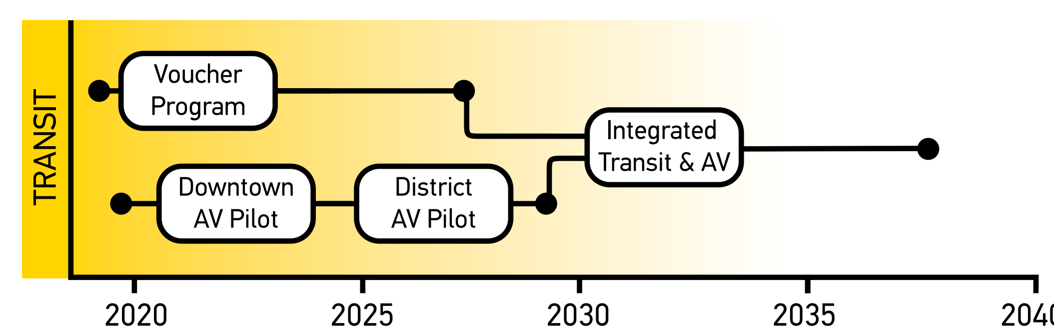


Figure 36: Transit recommendations timeline (Source: Authors)

EFFICIENT ASSET MANAGEMENT

Automated vehicles have the potential to significantly change the demand for space in cities, as privately-owned AVs may be able to park in the lowest-priced areas, while shared AVs are expected to be in constant operation, stopping only to pick up or drop off the users (Fagnant & Kockelman, 2015). On the other hand, a shift in transportation preferences among the urban population and an increasing number of millenials and seniors who prefer not to drive (Sivak, 2016; Alsnih, 2003), are yet another sign of a potential near future where the built environment of Iowa City may undergo significant changes. It is strategically important, especially in a climate of limited funding, that available municipal funds are invested to bolster resident's quality of life and not be wasted on infrastructure that might become obsolete, like new parking structures, whether private or public.

Iowa City, as a community that cares for the quality of its built environment and bicycle/pedestrian experience of its citizens, exemplifies best practices of smart planning and land-use through the use of parking maximums for its downtown areas (Zones CN-1, CB-5 and CB-10) and the introduction of form-based code in the Riverfront and Downtown district. Despite benefiting from the presence of the major educational and medical institution, Iowa City experiences the pressure of incoming students and growing workforce on its housing stock and parking facilities.

As is the case for many other U.S. communities (Shoup, 2018), parking is a complicated topic in Iowa City as evidenced by high levels of opposition to parking reduction. Two pertinent examples of this opposition were seen in the case of the building of the new Shelter House (Bontrager Auto Service Inc LLC v. Iowa City Board of Adjustment, 2008) and the past proposals for rental caps in Iowa City neighborhoods (Arnold, 2018). An examination of local media reports revealed respondents' concerns with the lack of parking spaces downtown (Dobrian, 2018), the need for discussions in planning a steady parking supply increase to accommodate new commercial and residential developments (Mims, 2018), and the commissioning of parking studies (Senstad, 2016). These concerns raised by residents all signal the necessity of a data-informed update of Iowa City's parking management policies.

The planning team conducted a comprehensive inventory of existing parking supply in Iowa City, researched the extent of parking spillover into neighborhoods adjacent to the downtown district and identified the main transportation-related land use challenges that Iowa City faces now in order to provide a set of short-term performance improvement recommendations and guide the community's investments and developments in the long term.

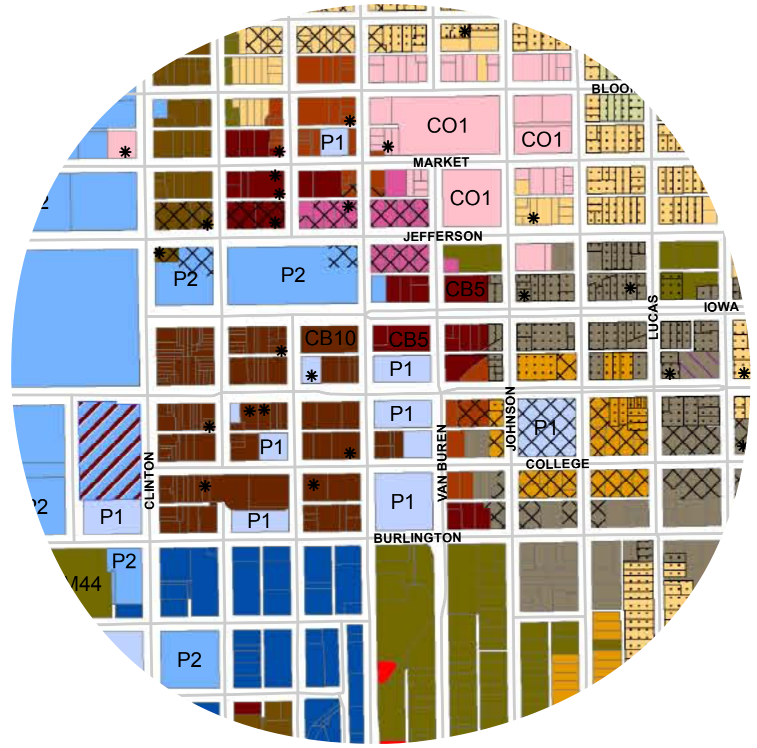


Figure 37: CBD land use (Source: City of Iowa City)

PARKING INVENTORY

Iowa City currently holds approximately 20,285 controlled-access parking spaces throughout the City that vary by type, size, and ownership. Among these spaces, 68% are owned by the University of Iowa with 24% of these spaces managed by the City of Iowa City. 51.5% of spaces are located in off-street surface lots, while 42.7% of stalls are put in the structured facilities.

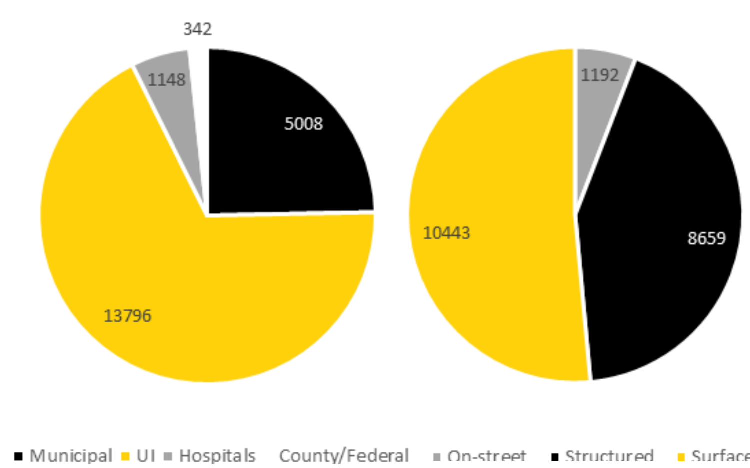


Figure 38: Controlled-access parking spaces by ownership and type (Source: Authors)

On-street metered parking accounts for only 5.8% of the total controlled-access spaces, which illustrates a demand of 64 residents per space. While it looks high from first glance, it's still 34% lower compared to New York, NY

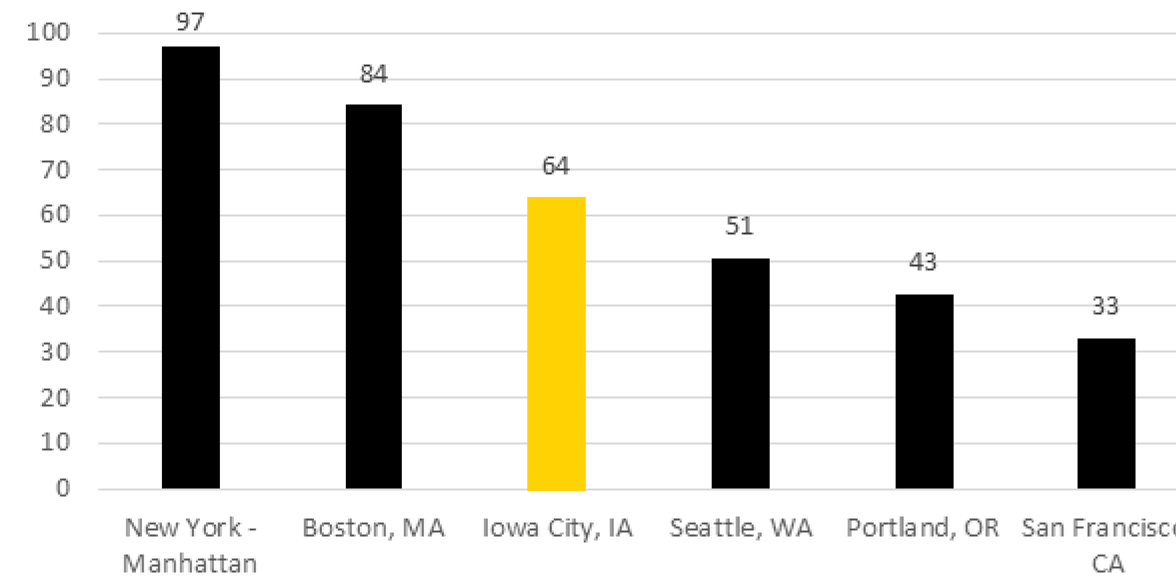


Figure 39: Population to metered on-street parking ratio (Source: Authors)

and 24% lower compared to Boston, MA.

When it comes to the downtown district, data shows that the share of university-owned parking drops more than 6.5 times compared to the citywide number, while the municipal stalls account for largest share in the downtown district (47.6%). Finally, private and residential parking accounts for 28% of total downtown parking.

With more than a half of downtown parking concentrated in multi-story garages, Iowa City still devotes roughly 19% of its downtown area exclusively to car storage. While it's in the same range with cities of similar population like Silver Springs, MD and Portland, ME, the comparison to the other U.S. college towns with significantly higher number of residents brings a whole new perspective to the understanding of effectiveness of Iowa City's current land use policies. Such cities as Berkeley, CA and Cambridge, MA have only 6% and 3% of total CBD land devoted to parking respectively. Converting that data into density, we see that there are only a few areas in Iowa City's downtown where there is no parking at all, predominantly near the Pentacrest and next to the Iowa River. The prevailing density for parking is below 50 spaces per acre, however it significantly increases in the southern part of the downtown district and reaches its maximum in the areas where structured parking is located.

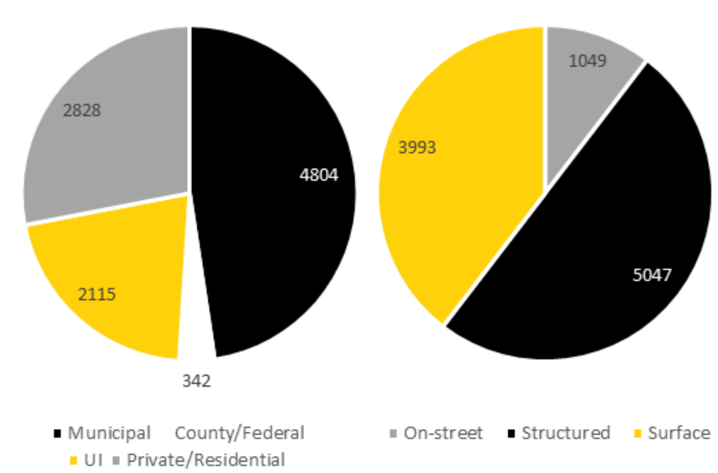


Figure 40: Iowa City downtown all parking spaces by ownership and type (Source: Authors)

City	Year	Land %	Population[1]
Silver Springs, MD	2010[2]	22%	76,716
Portland, ME	2017[3]	22%	66,882
Iowa City, IA	2018[4]	18.9%	75,798
Hartford, CT	2000[6]	18%	123,400
New Haven, CT	2000[2]	16%	131,014
Berkeley, CA	2000[2]	6%	122,324
Cambridge, MA	2000[2]	3%	113,630

Sources: [1] ACS 2017
[2] Johnson, Matt, "Parking Takes Up Space", Greater Greater Washington. July 23, 2010
[3] Fort Hill Infrastructure. "City of Portland Parking Study for Downtown, The Old Port, and The Eastern Waterfront". September 2017
[4] Authors
[5] McCahil, Chris et. al. "Visualizing Urban Parking Supply Ratios". Congress for New Urbanism 22nd Annual Meeting, Buffalo, NY June 4-7, 2014.

Table 6: Percentage of downtown land area devoted to parking

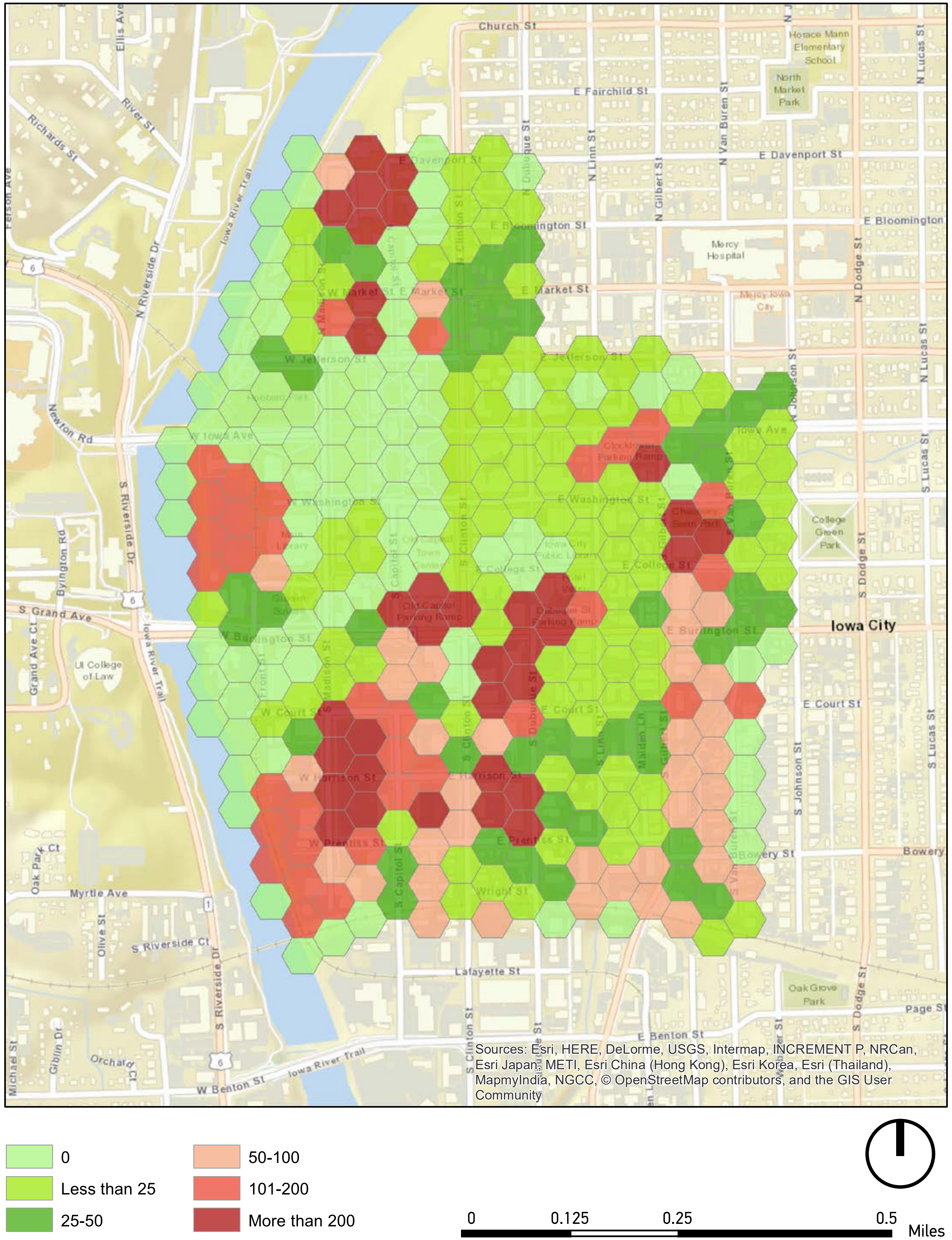


Figure 41: Downtown parking density - stalls per acre (Source: Authors)

NEIGHBORHOOD ON-STREET PARKING

The long-term expectation of AVs to be parked only in remote areas, as well as the creation of pick-up and drop-off zones discussed in the previous sections can allow for the elimination of downtown parking in the future, meaning that adjacent neighborhoods can fall victim of parking spillover. To effectively tackle this, better management of neighborhood ROW should be explored.

The team performed a parking study, aimed at discovering the effect of parking spillover associated with the downtown district. It was conducted over the course of one week, in the evening of October 10 and morning of October 11 for the Eastside sample and in the evening of October 14 and morning of October 15 for the Northside sample, between 10-11 AM for the day, and 10-11 PM for the night.

Before going into the results, it's important to note the limitations to the approach. First of all, it is subject to sample size, and since the conditions were examined only once and not during multiple counts over various seasons and weather conditions that could be averaged, it should be perceived as a snapshot of on-street parking usage. Though it improves the understanding of neighborhood occupancy, it still can't be treated as a full representation of the area but rather as first step for a more deliberate study conducted by the City.

For the purpose of the analysis, each sample is divided into 5 sections, starting from the downtown. Table 7 presents the samples' averages. For the Eastside Sample, the average night occupancy was 84% and increased to 94% during the daytime. 61% of cars from the evening count remained in place during the business hours of the next morning, however, once examining each part separately, it is possible to observe that the share of permanently parked cars in the first three sections is larger.

The Northside Sample had a slightly lower occupancy in the evening, averaging 62%, however, the occupancy rate rose to 97% the following morning, which is likely explained by the presence of a number of medical facilities in close proximity. The share of permanently parked cars is also lower (48%), compared to the Eastside Sample, however the drop from the first to last section was more than four times greater.

Overall, both samples show a normal or below normal occupancy rate (which according to the industry standard is 85% (Shoup, 2005) during the night hours, and almost full usage of curb space during the day which means that neighborhood residents who prefer to leave their vehicles in the public right-of-way should be able to find a vacant spot on the block when they come from work.

On the other hand, the study reveals an above average presence of permanently parked vehicles in the first three sections of each sample. Accounting for the university impact area and dominance of student multifamily hous-

Section	Total	Occupied Night	Occupied Day	Long-term	% Night	% Day	% Long-term
1	38	36	38	27	95%	100%	71%
2	26	21	26	20	81%	100%	77%
3	49	36	48	29	73%	98%	59%
4	33	25	33	13	76%	100%	39%
5	52	48	41	31	92%	79%	60%
Sample Total	198	166	186	120	84%	94%	61%

Table 7: Parking study for the Eastside Sample (Source: Authors)

Section	Total	Occupied Night	Occupied Day	Long-term	% Night	% Day	% Long-term
1	11	11	11	10	100%	100%	91%
2	49	39	49	29	80%	100%	59%
3	32	21	30	18	66%	94%	56%
4	38	20	37	13	53%	97%	34%
5	30	8	28	6	27%	93%	20%
Sample Total	160	99	155	76	62%	97%	48%

Table 8: Parking study for the Northside Sample (Source: Authors)

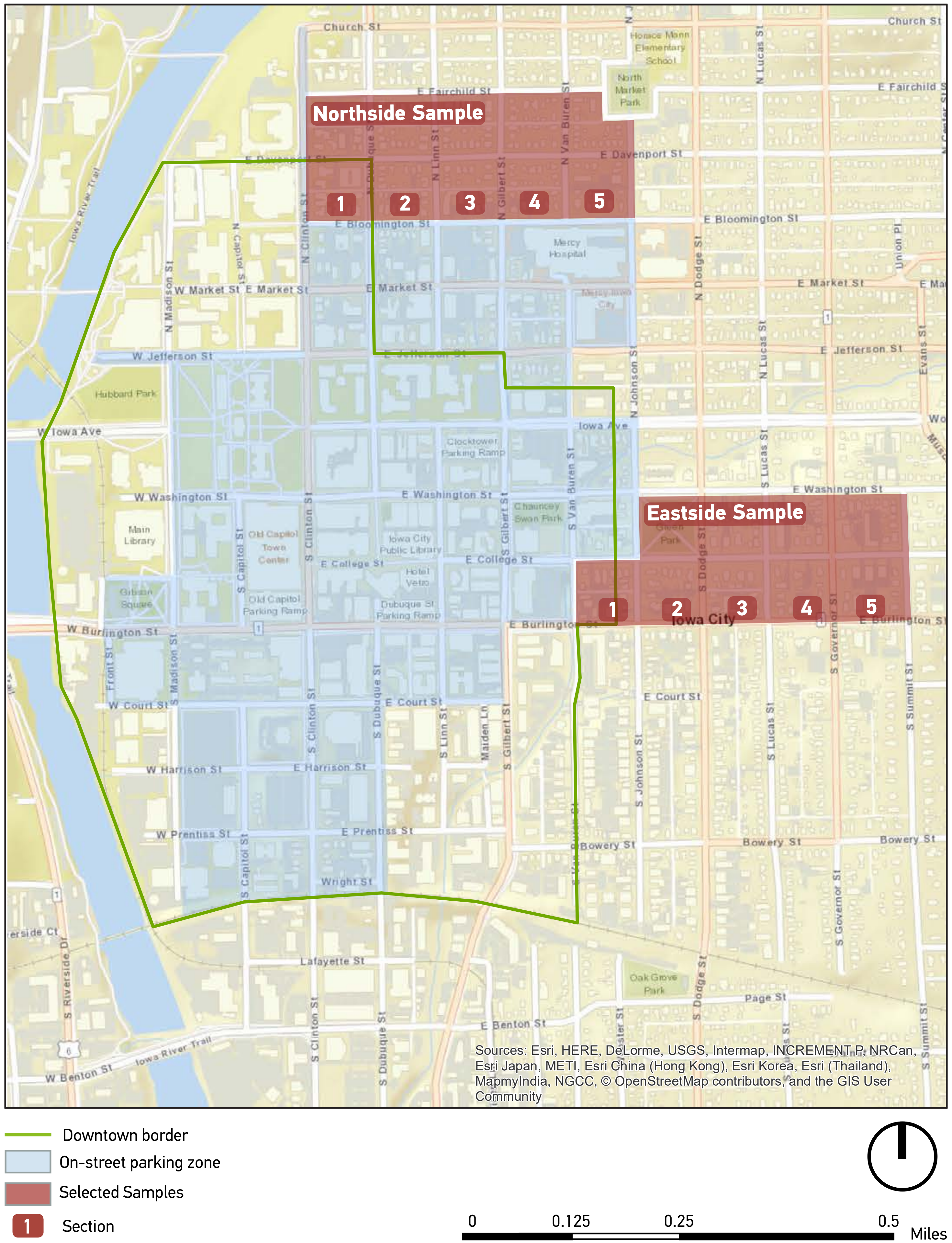


Figure 42: Neighborhood parking study samples (Source: Authors)

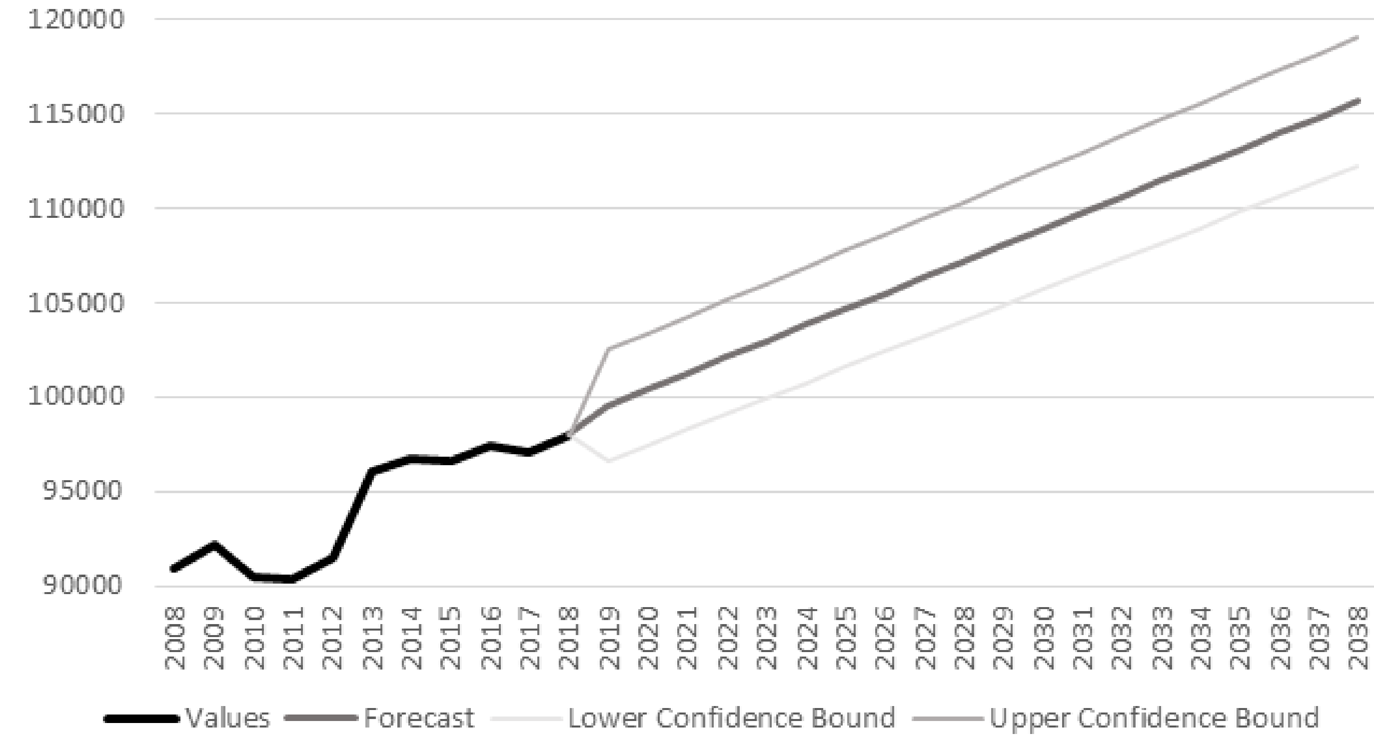


Figure 43: Iowa City MSA employment projection (Source: BLS)

ing, it can be implied that a lot of them utilize driveways for the storage of private cars, which they don't use on a daily basis.

PARKING DEMAND SCENARIOS

According to the Bureau of Labor Statistics (BLS), Iowa City has displayed a steady growth in terms of population and employment over the last decade, with a lower unemployment rate than that of the state of Iowa. If this trend is maintained into the future, the 98,023 jobs in the metro area will reach 115,669 by 2038 – an 18% increase over the 20-year period. With the prevalence of current commute patterns, the same increase in parking demand can also be expected.

Of course, it is impossible to predict whether this increase will take place downtown or in other areas of the City. However, given that two major employers - the University of Iowa and the University Hospitals - are located centrally, as well as numerous new high-rise developments that pop up, one could anticipate growth to occur in downtown employment too. The implication here is that if the current travel pattern prevails and 56.7% of commuters drive in a single-occupant vehicle (SOV), the demand from those 17,646 new jobs will require a supply of approximately 10,000 new parking stalls, if one assumes that existing parking stalls are 100% occupied. Given that in current conditions Iowa City uses its existing parking lots for new residential developments (Schmidt, 2015) it is unlikely that the additional supply can take the form of surface lots and will thus require the construction of additional parking ramps. The average size of a ramp in Iowa City is 600 stalls with a footprint of approximately 35,900 sq. feet; to satisfy the projected demand for parking, Iowa City will have to provide 17 new parking struc-

Name	Places	Price/Hour	First hour free	Automated
Tower Place and Parking	510	$1	Y	N
Dubuque Street Ramp	625	$1	Y	N
Capitol Street Ramp	875	$1	Y	N
Chauncey Swan Ramp	475	$0.75	N	Y
Court Street Transportation Center	600	$1	Y	Y
Harrison Street Parking Ramp	550	$0.75	N	N

Table 9: City-owned parking ramps (Source: Authors)

tures, which will require over 610,300 sq. feet of land with 5-story complexes and equal almost 4 new blocks on the city map.

Moreover, with the estimated cost averaging between $35,000 to $45,000 for construction, maintenance and operation of each structured parking space (SRF Consulting, 2018), such infrastructure expenditures may require as much as $350-$450 million of funding to accommodate the same trend of car usage over the next 20 years.

On the other hand, the reduction of SOV level to 45%, as it is stated in the City's climate goals (Iowa City, 2018), effectively reduces the projected demand for new spaces by approximately half (assuming that the use of existing stalls also falls), requiring the provision of 5 thousand new parking spaces in the next 20 years, holding everything else constant. As the team's outreach efforts suggest, the increase in service area and frequency of public transit may further decrease the demand for parking spaces in Iowa City, as respondents mentioned their willingness to forgo daily car usage if City bus system becomes more reliable and better connected.

AV POLICY PROPOSAL: NON-CAPITAL ADAPTATION OF PARKING & LAND-USE

At this stage, it is too early to rely on the promise that automated vehicles can reduce the use of parking, as there is no real-world evidence outside the models that assume such possibility. However, the speed of technological development also requires additional vigilance of the local government, should the predictions indeed prove to be true, and the demand for parking will be significantly lower due to AVs in the future, the repay of a parking ramp may be significantly longer than the usual 20-year period, if it happens at all. Given this, it is recommended that the City focuses on non-capital solutions for its parking decisions, like a residential parking permit program (RPPP), before more evidence becomes available.

On the other hand, the City already has an established practice of off-street parking maximums for its central business district, and the team suggests expanding it to the areas where alternative means of transportation like transit, carsharing or active modes are equally available (0.25-mile radius around high-frequency transit lines). Furthermore, this may effectively support the deployment of shared automated vehicles, discouraging the use and ownership of private cars.

Finally, a set of considerations for new developments are discussed in this section. Those recommendations intend to preserve multimodal and pedestrian landscape of the City, as well as allow a safe deployment of shared automated vehicles.

INTERIM MEASURE: RESIDENTIAL & COMMUTER PARKING PERMIT

Parking regulation and management is a complicated topic, as it involves numerous interests, and can influence both positively and negatively travel behavior, retail activity and level of emissions in any community, depending on the type of policy executed (Shoup, 2005). That is why it is extremely important that any changes in and improvements of parking are supported with robust quantitative data and sound analysis. Given that, this part of the short-term mobility plan focuses mainly on the recommendations based on the conclusions of neighborhood parking occupancy study. In the short term, this can expand the availability of parking options in the City by reducing the occupancy level to the industry-accepted standard of 85%, while in the long run it will ensure the availability of curb space for the pick-up and drop-off of passengers of automated vehicles.

Given the full daytime occupancy of on-street parking in the studied neighborhoods, the introduction of residential parking permit program is a solution that allows for limited the use of driveways for parking only to the residents of that neighborhood (FHWA, 2017). However, given the case of Iowa City, this measure can become a successful extension of publicly available parking in the downtown area, better management of student-owned cars as well as an additional source of revenue for the community.

Out of the 12 largest urban areas in the State of Iowa, only 3 of them have a parking permit program in place. This is a signal of a low general awareness of the benefits of parking management among Iowans. The team suggests the program to be implemented as a staged process, starting from the two areas studied for this report, and later expanded when the City obtains new requests for permit zones and evaluates the necessity using the methodology described in the research part of this study. Moreover, given the aforementioned inquiry for the parking permit program from the residents in those areas, it is expected that the public perception is conducive enough for a pilot implementation.

The primary goal of the parking permit program is to increase the availability of parking in the public right of way of the neighborhoods next to the downtown metered zone during regular business hours. In order to succeed, the endeavor should be finetuned to local conditions and goals:

City	RPP	Permit Price	Population[1]
Des Moines	Yes	$25-$50/ month	217.521
Cedar Rapids	No	X	132,228
Davenport	Yes	$40/ month (Ramp) $150/month (On-street)	102,320
Sioux City	No	X	82,514
Iowa City	No	X	75,798
Waterloo	No	X	67,587
Ames	No	X	66,498
West Des Moines	No	X	65,608
Ankeny	No	X	62,416
Council Bluffs	No	X	62,316
Dubuque	Yes	$15/year	58,276
Urbandale	No	X	43,592

Source: [1] ACS 2017

Table 10: RPP in Iowan cities (Source: Authors)

- Effective time periods. As a starting point, a residential parking permit can be enforced during the same hours as the City's on-street parking – from 8 AM to 6 PM, Monday through Saturday, as a preventive measure from the downtown parking spillover effect. However, the exact timing can be further refined through discussions with residents, who might be well-aware of the occupancy peak hours, and thus prevent the expenditures on the parking counts and enforcement. This is the lesson learned from San Luis Obispo, CA, in which this approach allowed the community to mitigate the challenge of commuters (mainly students and teachers) parking in residential neighborhoods (RSG, 2016).

- Demand and Supply Balance. Due to the limited supply of on-street parking spaces, it is important to ensure that the amount of issued residential permits does not exceed the number of stalls, in order to prevent the hunting for free spaces, cruising and thus increased pollution. For this reason, it is crucial to identify the exact quantity of parking in the public right of way and constantly keep a record of the number of permits issued. Various U.S. cities provide different quantities of residential and guest permits per households, and a summary that is similar to Iowa City communities is provided in Table 11. However, it is the practice of Fort Collins, CO that deserves a particular attention, with its tiered approach for pricing, where the first permit for a household is free, while the fifth costs $200 in order to ensure the issuance of permits that are in actual need only (Fort Collins, 2018).

City	Residential permits per HH	Price (annual)	Guest permits per HH	Price	Commuter Permit	Population[1]
Ann Arbor, MI	5	$50	5	$50/year	X	121,477
Boulder, CO	2	$17	2	Free	$100/quarter	107,125
Charlottesville, VA	4	$25	2	$25/year	X	48,019
Fort Collins, CO	5	1st - free 2nd - $15 3rd - $40 4th - $100 5th - $200	No limit	Free/24 h $10/15 days	X	165,080
Rochester, MN	No limit	$20	No limit	$10/30 days	X	115,733
San Luis Obispo, CA	2	$15	Can use residential	X	X	47,541

Source: [1] ACS 2017

Table 11: Residential parking permits in the U.S. (Source: Authors)

• Multi-family and student housing. Given the case of Iowa City, where a large amount of housing in the next-to-downtown neighborhoods is occupied by students, it is important to effectively limit the total number of residential and guest permits per apartment building. Otherwise, if the City has uniform rules both for single and multi-family homes, a hypothetical spillover effect occurs, since a complex of 20 units, where each dwelling unit has a right for one residential and one guest permit, may easily occupy all on-street parking places on a typical block (RSG, 2016).

• Commuter permit. In order to increase the supply of parking spaces next to downtown, the City might consider allocating a certain amount of spaces for commuter spaces. Such practice exists in Boulder, CO, where 4 spaces per block are allocated to commuters, at a price of $100 per quarter. However, if a block faces a high demand of residential permits, the number of commuter permits can be decreased or totally repealed (Boulder, 2018).

PERMIT COST & FINANCIAL FEASIBILITY

In Iowa City, parking revenues and fees amounted to $5,910,725 in 2017 (Iowa Department of Management, 2019), which is 2.4% of total city revenues for that year. Since the introduction of a residential parking permit program will lead to an increase in public expenditures for administrative and enforcement services, the permit price will be able to pay for the program. Given that the primary objective of the policy is to efficiently manage the scarcity of public space, it is important the program is at least “cost-neutral” for the municipality, meaning that the RPPP application and annual fees recoup the full cost of administration, enforcement and monitoring of the program. Moreover, it can be expected that the policy might become a disincentive to park on the streets for residents, encourage efficient use of off-street spaces, and promote car-sharing and alternative modes as a measure that reveals the true cost of driving.

To calculate the tentative pricing scenarios for RPPP in Iowa City, the team used publicly available data on the $120,000 annual budget for the similar program costs for the City of Boulder, CO (RSG, 2016). Using preliminary re-

Scenario Name	Permit allocation	Permit Price	Total Revenue
Scenario 1	100% - residents	$15/year - residents	$14,730
Scenario 2	100% - residents	$122.2/year - residents	$120,000
Scenario 3	40% - commuters, 60% - residents	$25/month - commuters, $15/year - residents	$126,450

Table 12: Residential parking permit program scenarios for Iowa City (Source: Authors)

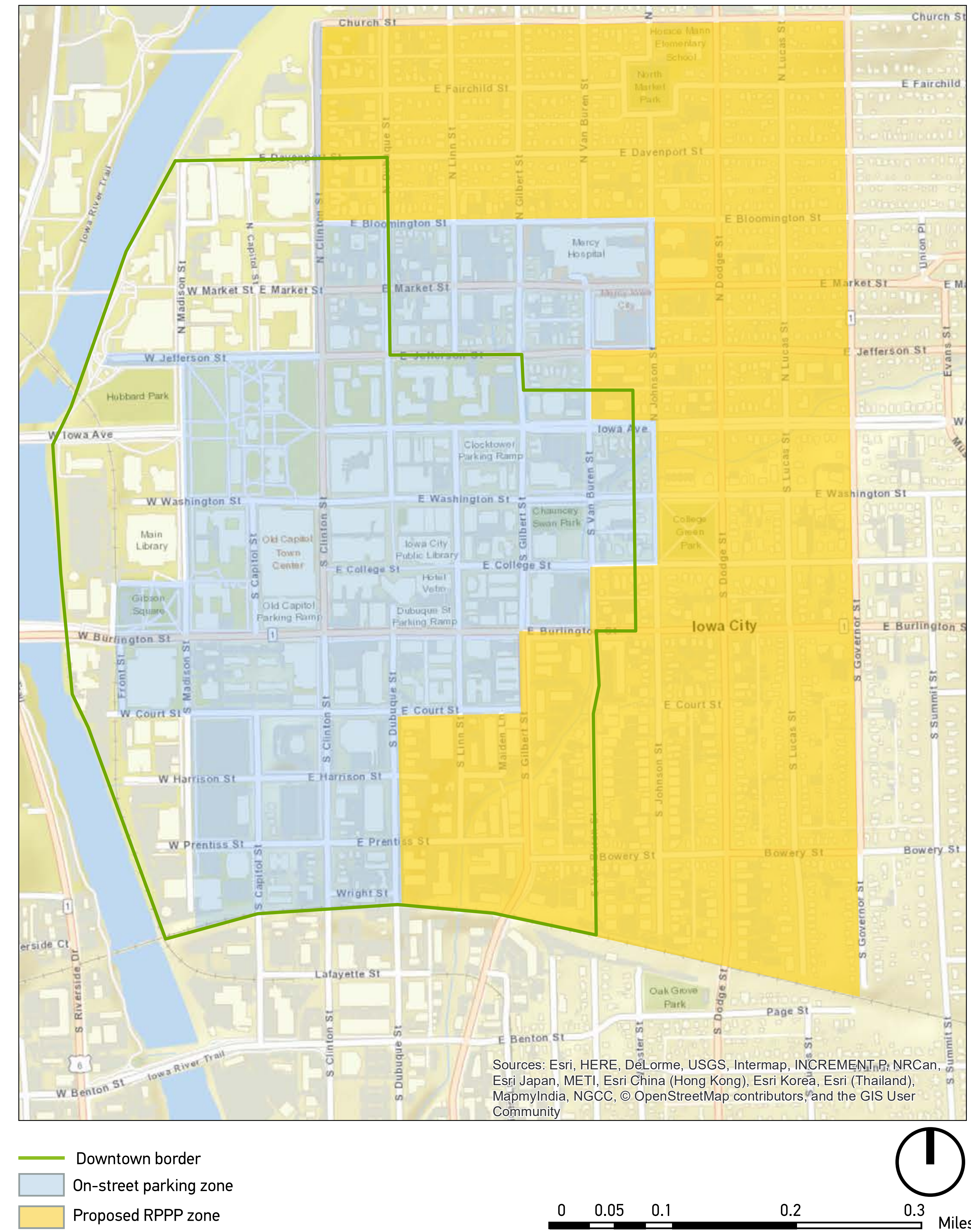


Figure 44: Proposed RPPP area (Source: Authors)

search, the team assumed that over time, the program might stretch over a 3 to 4 block buffer around Iowa City's downtown on-street enforced parking, encompassing as many as 982 parking spaces in the public right of way (see Figure 44). Following the logic that the number of permits should not exceed the number of available spaces (to prevent the space hunting and cruising) we used this number for our scenarios.

Obviously, at the initial stage it is hard to expect that separate zones will be able to yield $120,000 in Iowa City at a reasonable price per household, however, it is highly probable that it can be self-sufficient once in full operation. The different scenarios are presented in Table 12. As it shows, the introduction of the lowest price that the cities studied use of $15 per permit will require a significant public subsidy in order to allow the program operation. On the other hand, the $122.2 price tag will allow the program to break even in terms of cost and expenditure, however, it will be one of the highest prices among the cities of a similar size studied. Finally, following the experience of the City of Boulder and allocating 40% of spaces to commuter permits for a monthly price of $25 allows Iowa City to keep the price for residential permits at the $15 level while producing enough revenue to cover the expected cost of the program.

REDUCTION OF PARKING REQUIREMENTS

As numerous authors suggest, parking provision is extremely costly, and is often subsidized indirectly through taxes and higher prices of other products, effectively lowering the cost of car usage and requiring zero or fewer than average vehicle households to also pay for the space they do not use (Litman, 2017). This rises significant equity concerns and effectively drives up the cost of new housing construction (Shoup, 2005), thus a reduction of parking requirements should be of interest for the local government. Given that the establishment of parking maximums, or even elimination of parking requirements in Iowa City requires additional research and improvement of public transit and active transportation infrastructure, a gradual decrease of parking minimums is recommended based on the factors provided in Table 13.

Areas that satisfy the requirements of multiple factors require additional attention, as research suggests that adjustments in those cases are not additive but should be applied to the base level reduced by previous factors. For example, land use mix may reduce requirements by 20%, carsharing to 90% of the base level, and specific

Factor	Description	Typical Adjustments
Geographic Location	Vehicle ownership and use rates in an area	Adjust parking requirements to reflect variations identified in census and travel survey data. 40-60% reductions are often justified in Smart Growth neighborhoods
Residential Density	Number of residents or housing units per acre/ hectare	Reduce requirements 1% for each resident per acre (e.g. 15% where at 15 residents per acre and 30% at 30 res. per acre)
Employment Density	Number of employees per acre	Reduce requirements 10-15% in areas with 50 or more employees per gross acre
Land Use Mix	Land use mix located within convenient walking distance	Reduce requirements 5-15% in mixed-use developments. Additional reductions with shared parking
Transit Accessibility	Nearby transit service frequency and quality	Reduce requirements 10% within ¼ mile of fr quent bus service, and 20-50% within ¼ mile of a rail transit station
Carsharing	Whether carsharing services are located within or near a residential building	Reduce residential requirements 10-20% if carshare services are located onsite, or 5-10% if located nearby
Walkability and bikeability	Walking environment quality	Reduce requirements 5-15% in very walkable and bikeable areas, and substitute bike parking for up to 10% of car parking
Demographics	Age and physical ability of residents or commuters	Reduce requirements 20-40% for housing occupied by young (under 30), elderly (over 65) or disabled people

Table 13: Parking requirement adjustment factors (Source: ITE, 2016)

demographics to 60%, which, if applied jointly lead to a 80% x 90% x 60%=43% required level, or 57% reduction, that is lower than the rate obtained from mere adding – 20%+10%+40%=70%. On the other hand, some requirements may have a higher effect if applied together and should be always evaluated using professional judgement and through understanding of a specific location (Litman, 2017).

With this approach, Iowa City can join several progressive U.S. municipalities in the process of rethinking parking requirements as a means to increase the quality of the built environment and affordability of housing. Buffalo, NY eliminated its minimum off-street parking requirement in 2016, and is still the only U.S. community to do so citywide, while Rochester, MN has done so only for its downtown area (Steuteville, 2016). With its new comprehensive plan, Minneapolis, MN has also declared an intention to follow Buffalo's approach to parking policy (Schmitt, 2018). Finally, San Diego, CA has just recently passed a parking reform package, replacing parking minimums with maximums for transit-adjacent areas and the downtown (Nguyen, 2019).

AV CONSIDERATIONS FOR NEW DEVELOPMENTS

While the pace of and direction of technological development of autonomous technology allows for a gradual adaptation to the existing urban environment, it is the planning and development of new neighborhoods that creates a distinctive set of challenges for the local government. Following the paradigm unveiled in this report that argues for the opportunity and necessity to increase the equity, sustainability and affordability of life in Iowa City, the team recommends the City to consider the update of planning policies that can allow future neighborhoods to be conducive to active modes of transportation, public transit and other shared modes, including automated vehicles.

• Transit-Supportive Incentives

At present, Iowa City does not have a city-wide policy that facilitates the development of a transit-oriented environment. The only existing provision is a part of Riverfront Crossings and Eastside Mixed Use District Form-Based Development Standards, that allows height bonuses to those developments that dedicate some of its land for public rights of way necessary to realize the vision of the area (City of Iowa City, 2016). While this policy should be extended for other areas of high density, it is highly unlikely that it may result in any change for the traditional neighborhood setting. That is why for new developments that support a transit-oriented layout and planning the City should consider incentives like density bonuses, flexibility in development regulations, fee waivers or reductions, and permitting priority. These approaches are often referred to as incentive zoning, and their usage can be an effective means for establishing the consideration of shared mobility in residential and commercial developments (Cohen & Shaheen, 2016). By utilizing incentive zoning, the City of Iowa City could continue to maintain the pedestrian friendly environment envisioned in the Comprehensive Plan and other pertinent planning documents while further addressing the mobility needs of current and future residents. Such practice already takes place in Los Angeles County, where bonuses are designed to increase the financial feasibility of developments that align with community goals and support the use public transportation (LA Metro, 2019a).

• Reduction of Parking

The argument for off-street parking reduction has been developed in the previous sections of this report, however, the growing competition for the curb space now, as well as anticipated demand from automated vehicles, suggests that cities should eliminate on-street parking for the future residential neighborhoods (NACTO, 2017). The safety benefits of parking-free streets were documented long ago (Humphreys et al., 1977), though it is only recently that cities have systematically approached the matter as a reason to remove parked vehicles from the roads (Dawid, 2019). Importantly, the common solution to protect bicycle lanes from the moving vehicles with parked cars does not provide ubiquitous access to curbs that current ride-hailing services and future AVs require, and thus should not be considered for new subdivisions.

On the other hand, there is a chance for reluctance that developers might express toward elimination of parking minimums suggested above, as older city neighborhoods still offer the same amount of parking spaces, and thus might be valued more by certain populations. To effectively tackle this, it is suggested that the City allows parking and housing to be unbundled and priced separately for new developments, effectively decreasing the price of homeownership (Shoup, 2005) while still providing an option for those who are willing to pay. However, it is recommended that parking is located outside the primary street frontage and consolidated in districts or shared areas, so in case of low demand it can be redeveloped for other effective uses (LA Metro, 2019b).

The first step towards that direction can be in developing a "parking substitution" regulation for existing and proposed residential and commercial developments that

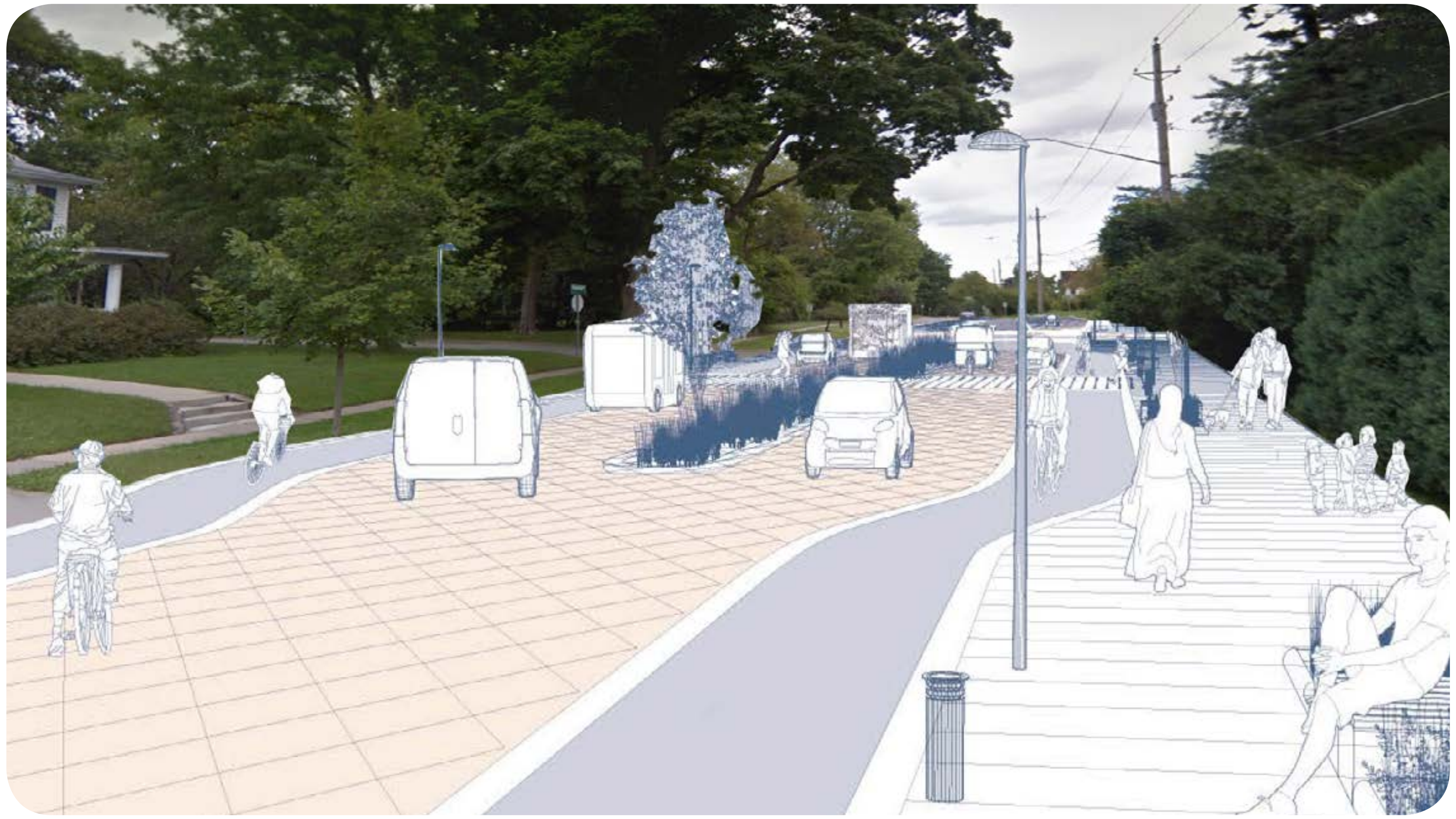


Figure 45: Layout for neighborhood main street (Adapted from NACTO)

allows developers and property owners to convert a proportion of existing/proposed parking spaces to be used for shared modes (i.e. bikeshare facilities, TNC parking spaces) in the downtown area and other higher density residential areas.

• ROW Layout

In terms of space allocation in the right of way the team recommends following the approach developed by NACTO, that prioritizes the safety and quality of the built environment in planning new subdivisions. The speed limit of 20 mph creates the environment where all of the modes can seamlessly operate at the same velocity in its reserved lane, with the median being a flush lane.

Residential streets should be the spaces where residents are prioritized, and their safety and possible scenarios of use are considered in the layout. The speed should

City	Regulation	Description
Seattle, WA	Revised Parking Requirements	Municipal code allows reduction of up to 5% of total required parking spaces for developments that include infrastructure for carsharing programs. For commercial developments, the number of required parking spaces may be reduced by either 3 spaces or 15% of total required parking spaces for carsharing programs
Vancouver, WA	Transportation Impact Fees (TIF)	Developments that encourage alternative transportation modes receive reduced Transportation Impact Fees and residential density bonuses
Indianapolis, IN	Parking Reductions for Shared Mobility Infrastructure	Developers may reduce the amount of parking spaces constructed by up to 35% for constructing: shared vehicle spaces, electric vehicle charging stations, bicycle parking, developments in close proximity to transit stops

Table 14: Zoning and subdivision regulations for shared modes in other U.S. communities (Source: Authors)

Figure 46: Layout for neighborhood residential street (Adapted from NACTO)

be limited to 10 mph, with most of the traffic being either local or deliveries.

Outcomes of Revised Zoning and Subdivision Regulations:

• Increased usage of shared modes, leading to reductions in the number of single-occupant vehicle trips made in the City's transportation system;

• Reduced demand for parking facilities in existing and proposed residential and commercial developments; and

• Increased residential density in the Downtown and Riverfront Crossings areas, leading to increased support for transit and other shared modes.

Measures of Success in Implementing the Revised Zoning and Subdivision Regulations:

• Define a baseline trend for the usage of shared modes in Iowa City and monitor shared mobility usage annually to assess changes in the residential use of these transportation modes.

• Develop goals for percentage of parking spaces in proposed residential and commercial developments allocated to shared modes.

• Develop a goal for desired residential densities in the Downtown and Riverfront Crossings areas and monitor the annual changes for this goal to ensure higher density development is occurring in these areas.

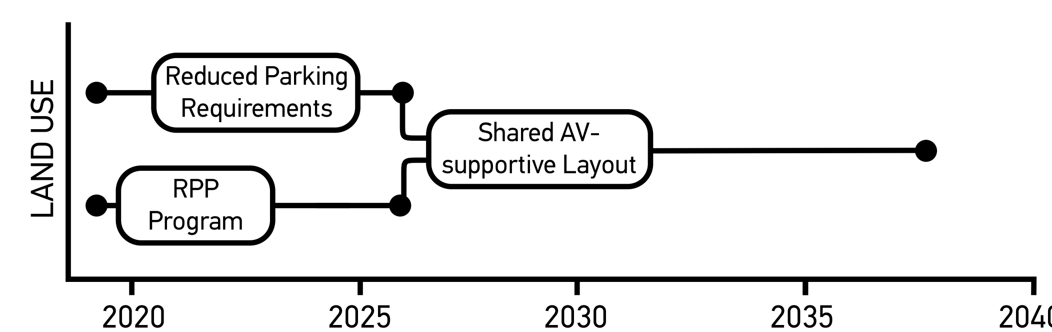


Figure 47: Land use recommendations timeline (Source: Authors)

ENVISIONING THE AUTOMATED FUTURE

THE NEED TO ADAPT

Integrating AV shuttles in to the transit system could be an effective strategy for Iowa City in pursuing the transportation emissions goals set forth in the Climate Action plan. Not only can Iowa City further its ability to reach the Climate Action goals, utilizing automated shuttle technology in the transit fleet could improve frequency and coverage of transit routes while reducing residents' dependence on private automobiles. This unique value proposition for the transit system could result in several benefits summarized below:

- Make Iowa City transit a competitive mode in the transportation system of Iowa City and increase ridership levels.
- Foster a more attractive transportation option for a variety of road users, including both people with and without access to private vehicles.
- Guide Iowa City towards achieving its transportation emission reduction goals.
- Better connect residents with active transportation and shared mobility modes, leading to increased mobility for all residents.

DECREASING EMISSIONS

Iowa City's Climate Action and Adaptation Plan articulates the City's the goal to divert 55 percent of trips taken in private vehicles to sustainable and active modes of travel such as transit, bikes, and walking by the year 2050 in order to reduce greenhouse gas emissions associated with transportation. However, with the current declining trend of transit ridership, this goal will be difficult to achieve. Furthermore, research suggests that transit trips taken with low ridership levels contribute to higher per capita GHG emissions compared to trips taken in private vehicles.

According to APTA (2008), the National Transit Database, and FTA (2010), the average bus occupancy in the United States is nine passengers. In Iowa City, transit buses serve 28.4 rides per revenue hour and 14.2 rides per transit route (most Iowa City transit routes were designed to complete a loop within 30 minutes). Nonetheless, these 14.2 passengers do not continuously occupy a spot on a bus. Considering the average transit travel time of Iowa City residents (assuming a 15-minute average travel time per passenger), it can be found that transit buses carry an average of 7.1 passengers at a time. A traditional bus, fueled by diesel, must carry a minimum of seven passengers at all times to outweigh the per capita emissions compared to those emitted by a personal vehicle carrying one passenger (FTA, 2010). Thus, it can be estimated that per capita emissions from Iowa City transit is very close those of a private vehicle with a single occupant due to the low transit ridership levels. Additionally, considering Iowa City transit operations during off-peak hours, it can be estimated that emissions from a transit buses are higher than those of a personal car due to low ridership levels during those periods. Therefore, continuing to operate on the current schedule and service of Iowa City's transit system will likely increase GHG emissions in the City in the long-run when coupled with an increased number of private automobile trips.

TRANSIT SCENARIOS

Two scenarios were considered to analyze the conditions of Iowa City with automated technology integrated into the transit system. The first scenario was a business as usual scenario, in which the current trends in Iowa City's transportation system were extrapolated out to 20 years in order to visualize what may likely happen if the City continues its current measures without any changes to the transit system. In the second scenario, the planning team explored the potential implications for Iowa City after a 20-year period in which the transit system has transitioned to an automated fleet.

SCENARIO 1: NO CHANGE

In the business as usual scenario, the planning team identified a series of potential implications resulting from the perpetuation of the current transit operations in the areas of transit service and ridership, vehicle miles traveled and GHG emissions, and intermodal competition.

Implications on Transit service and ridership:

- If the frequency of transit service does not increase and if innovation is not introduced into the transit system, then it will lead to a continuous decline in transit ridership.
- The current service area of the Iowa City transit is 8.53 square miles which will continue with little or no change (detail of service analysis is described in the appendix). This service area does not adequately cover Iowa City.
- The mode share for public transit is currently less than 10%, and a continuation of business as usual could see this modal share decrease in the future.
- Lower ridership levels may compel the City to cut services in low ridership areas, which could lead to a further decline in ridership.
- The fare box ratio of the current transit system is 0.25, which would likely lead to a further decline in future years under this scenario.

Implications for Vehicle Miles Traveled and GHG Emissions:

- An increase in Iowa City's population and economic activities could shift commuting to private vehicles and lead to increased VMT and GHG emissions.
- Iowa City's current rate of increase for VMT is 3% per year, meaning a doubling in annual VMT from the current total of 322 million miles traveled to 688 million miles traveled in 2040 (Iowa DOT, 2015).
- A doubling of VMT by 2040 is predicted to result in 64 million kg of GHG emissions
- These added emissions could have substantial public health consequences such as rises in chronic diseases as well as failure to achieve the goal of reducing transportation emissions set forth in the Climate Action Plan.
- Increased VMT would likely lead to a decrease in the level of service of the current road infrastructure, resulting in the building of more road infrastructure to meet the demands of increasing traffic and thus, greater public expenditures.

Implications for Intermodal Competition

- The increase of economical ride-hailing options could cause residents to shift to these emerging services, resulting in a further decline in transit ridership (Graehler,Mucci, and Erhardt, 2018).
- Increased reliance on private vehicles could denigrate the pedestrian-friendly environment of Iowa City and further exacerbate the mobility challenges of residents.

SCENARIO 2: AUTOMATED TRANSIT FLEET

The 20-year vision scenario sees a future transit system with a high frequency, door-to-door, on-demand service. Should Iowa City's transit system integrate automated vehicle technology into its fleet, there are range of potential benefits for transit ridership and service, VMT and GHG emissions, and public expenditures.

Scenario 1: Business as Usual	Scenario 2: Automated Transit Fleet
Ridership continuously declines	Ridership substantially increases
Higher investment in road infrastructure needed	Less investment in road infrastructure needed
Service Area: 8.53 square miles	Service Area: 15.68 square miles
VMT significantly increases	VMT remains constant or decreases
Difficulty achieving the Climate Action and Adaptation goals for the transportation sector	Assist Iowa City in achieving Climate Action and Adaptation goals for the transportation sectors
Higher GHG emissions	Lower GHG emissions
Poor value proposition as transit becomes costly to operate and cannot compete with TNCs	Attractive transit value proposition and competitive with inexpensive TNC operations
Consequences for public health from higher GHG emissions	Benefits for public health from lower GHG emissions

Table 15: Comparison of outcomes for the scenarios (Source: Authors)

Potential Benefits for Transit Ridership and Service:

• With the integration of AVs in the public transit system, Iowa City could see a substantial increase in ridership levels throughout the City due to increased reliability of the system.
• As transit ridership in most areas follows an exponential pattern, providing higher frequency service in these areas, can attract new transit users and further boost ridership.
• With two different types of automated vehicle shuttle service systems, the service area of the transit could increase to 15.68 square miles which is double the current service area of Iowa City transit (detail of service analysis is described in the appendix). This increased service area could offer additional transportation opportunities for Iowa City residents.

Potential Benefits for VMT and GHG Emissions:

• Increases in service frequency and service area are shown to have positive impacts on transit ridership as the elasticity of transit use to service expansion is typically in the range of 0.6 to 1.0, meaning that each 1 percent of additional transit vehicle-miles or vehicle-hours increases ridership by 0.6 percent to 1.0 percent (Litman, 2004).
• The elasticity of transit use with respect to transit service frequency (a headway elasticity) averages 0.5, with greater effects where service is infrequent (Litman, 2004).
• Together, these elasticities imply that it is possible for a significant modal shift from private vehicles to transit to occur, leading to decreased annual VMT.
• Decreased VMT is shown to result in lower transportation GHG emissions, meaning Iowa City could stay on track to meeting its Climate Action goals related to transportation.
• Less VMT means fewer private vehicles will travel in public roadways relative to the business as usual scenario.

Potential Benefits for Public Expenditures:

• Decreases in the use Iowa City's roads by private vehicles could result in the City needing to allocate less resources for maintaining and improving vehicle-oriented infrastructure.
• Potential monetary savings related to road infrastructure expenditures can be invested in the implementation of different strategies of the Automated Vehicles Adaptation Plan for the City.

TRANSLATING A SCENARIO INTO THE VISION

Using the promises of the second scenario, as well as the aims and goals of existing planning documents of Iowa City, the team crafted a vision for the City's transportation system which focuses on a transit system of a fixed route, high-frequency automated transit service capable of providing door-to-door service to Iowa City residents. Complementing future mobility modes, such as bicycles, ride-sharing, and ride-hailing, this fixed-route automated service can guide Iowa City toward the goal of connecting all Iowa City residents to the various opportunities and amenities the City has to offer. The improvement of the City's transit system by means of automated technology significantly benefits the other aspects of the built environment and for this matter are broken down into separate components of the vision.

The project team understands the importance of public participation and, therefore, has conducted a public open house to solicit input in order to receive feedback on the community-wide vision set forth in the plan as well as facilitate an opportunity for residents to discuss the outcomes they desire to see in Iowa City's future transportation system. These efforts were done so that there was no influence of a pre-determined outcome for public buy-in. The purpose of this initial open house was to begin understanding where the general public stands on the topic of innovative solutions to transportation challenges, as well as to draw a nexus to the stakeholder interviews conducted prior to the event. The team used the stakeholder feedback and literature research to craft visual depictions of what future scenarios may look like. The event allowed for flexibility with in-person interaction among the attendees.

The project goal for this initial public engagement process was to assess how the stakeholder opinions align with the opinions from the attendees of the general public. In doing so, focus areas within the scope of the project could be identified or emphasized, further guide the recommendation and visioning process. However, in the recommendation portion, it was found that the concept of driverless vehicle technology is still quite a nebulous topic for many of the participants of both the open house and the stakeholder meetings. Therefore, this open house event is recommended to be the first of a variety of public engagement efforts to be conducted in the realm of innovations in transportation and the role evolving technologies can play in the urban landscape. Furthermore, a public education program on transportation innovations may prove to be very helpful for all levels of Iowa City's public officials in future decision-making and the prioritization of planning projects.

The details for each vision component is discussed below. The responses are from both the open house and an online survey participants. The cumulative number of respondents for both sessions is 27, 18 from the open house and 9 from the online survey. The demographics of participants include a range of age, ethnicity, disability status, and gender.

VISION COMPONENT 1: FIXED ROUTE AND DOOR-TO-DOOR AUTOMATED PUBLIC TRANSIT

Iowa City's current transit system serves approximately 15,068 trips per day on a fixed-route network with high and medium frequency. Experts predict transit authorities can integrate automated vehicles into their fleets as these vehicles will be able to provide high-frequency services at much lower operating costs.

The public's feedback regarding the fixed route and door-to-door automated public transit was:

1. Assuming the price for using the transit system is the same, more than half of the respondents would continue to use their current mode of transportation, while slightly less than half of the respondents would choose a shared, door-to-door transportation service that runs on 15-minute intervals.

2. Comparing the current price of a trip on Iowa City transit of $1, more than half of respondents would not pay more than $1 for a shared, door-to-door transportation service that runs on a 15-minute interval.

3. The respondents' level of knowledge regarding AV technology is mainly gained through news coverage and media publications, and therefore, respondents have a basic understanding of AVs and related technologies.

VISION COMPONENT 2: INTEGRATED SHARED MOBILITY & ACTIVE TRANSPORTATION

Iowa City strives to maintain a pedestrian and bike friendly community that balances the feel of a big city with small town charm. Through extensive planning for bikes and pedestrians, Iowa City has developed dense, walkable neighborhoods that encourage residents to utilize all modes of travel while considering the needs and safety of all road users. The integration of automated vehicles in Iowa City roads could have the potential to compromise the pedestrian-oriented nature of the city, further exacerbating the mobility challenges of residents.

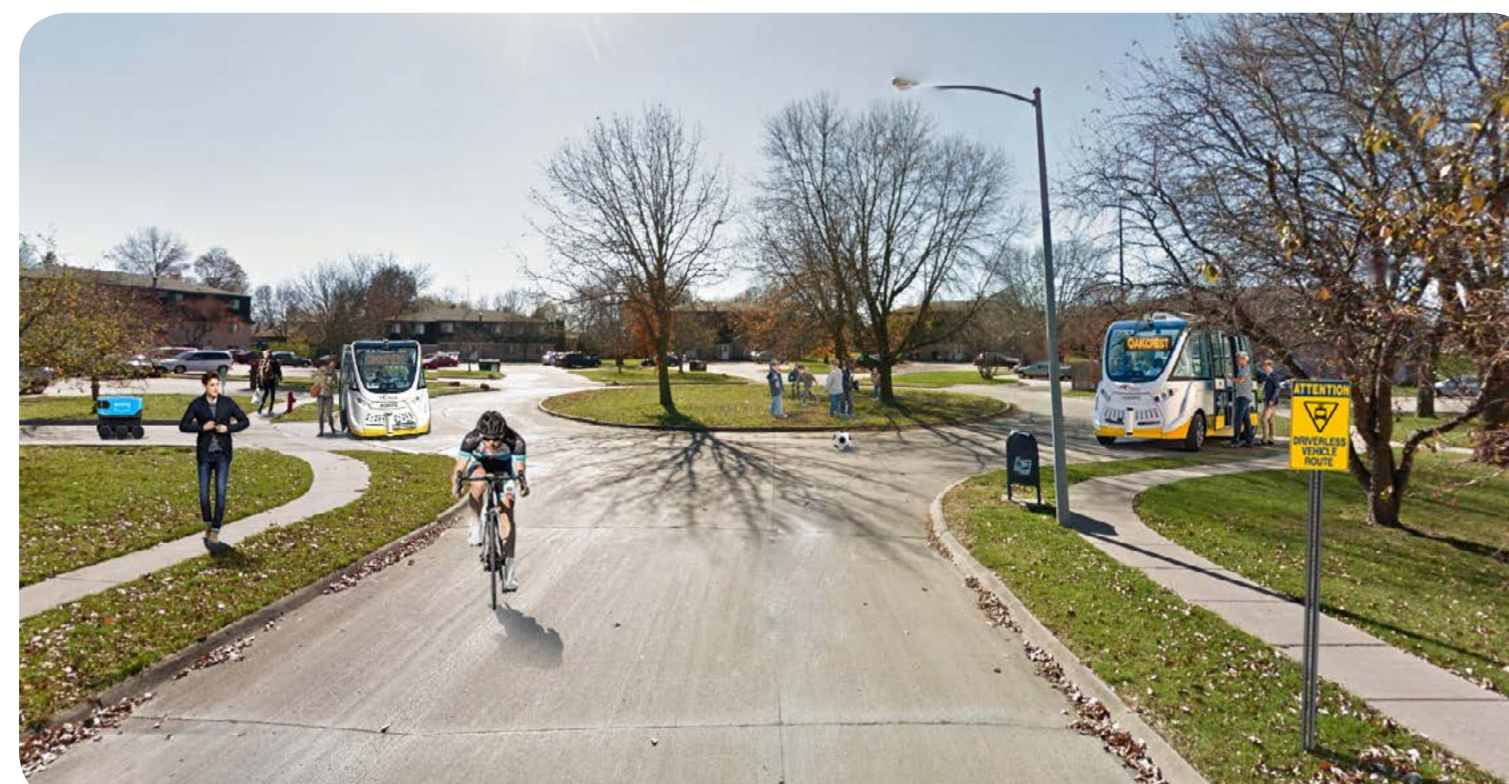


Figure 48: Fixed route and door-to-door automated public transit component (Source: Authors)

The 20-year vision for Iowa City's shared mobility and active transportation infrastructure ensures that Iowa City residents will not be stressed in accessing mobility modes as access to the transportation network will be, at most, a 5-minute walk. Additionally, the integration of automated vehicles will improve road safety to the point that traffic collisions are a relic of the past.

The summary of public's comments on the component:

1. More than half of the respondents have experience using shared transportation modes (Uber, Lyft, Iowa City transit, vanpool, etc.) in Iowa City. One respondent noted that they were unable to use most shared mobility due to their disability and the lack of wheelchair access.

2. Nearly all of the respondents would use a shared mode in lieu of a personal vehicle for daily trips if it took 5-minutes or less to access. The wheelchair access posed a barrier for one respondent.

3. In terms of receiving public investment, respondents were asked to rate which mode of transportation needed the most and the least attention from a ranking of 1-4 (one being the most important and 4 being the least important). 61% of respondents believed public transit was the most important to receive funding out of the four options, and 27% believed it to be second most important.

22% of the respondents ranked public investment in bicycle and pedestrian infrastructure (i.e. protected bike lanes) as most important and 55% believed it to be second most important.

72% of the respondents believed shared mobility should be the 3rd most important mode in receiving public funding.

The fourth option (write-in) found another vote for more wheelchair access and a vote for better roads.

VISION COMPONENT 3: TRANSPORTATION NETWORK COMPANIES & THE COMMUNITY

Transportation Network Companies, or TNCs, such as Uber, Lyft, and ZipCar, have shifted the way people travel today. While inexpensive, on-demand ride-hailing and ride-sharing have revolutionized urban travel, the operations of Transportation Network Companies can also negatively impact communities through competition with transit systems and increased congestion owing to additional trips made by low-occupancy automobiles.

The 20-year vision for TNCs operations in Iowa City could see the city partnering with companies like Uber and Lyft in order to better understand the impact these TNCs have on Iowa City roads. Through data-sharing and local regulations, Iowa City could collaborate with TNCs to ensure equitable access to the City's transportation

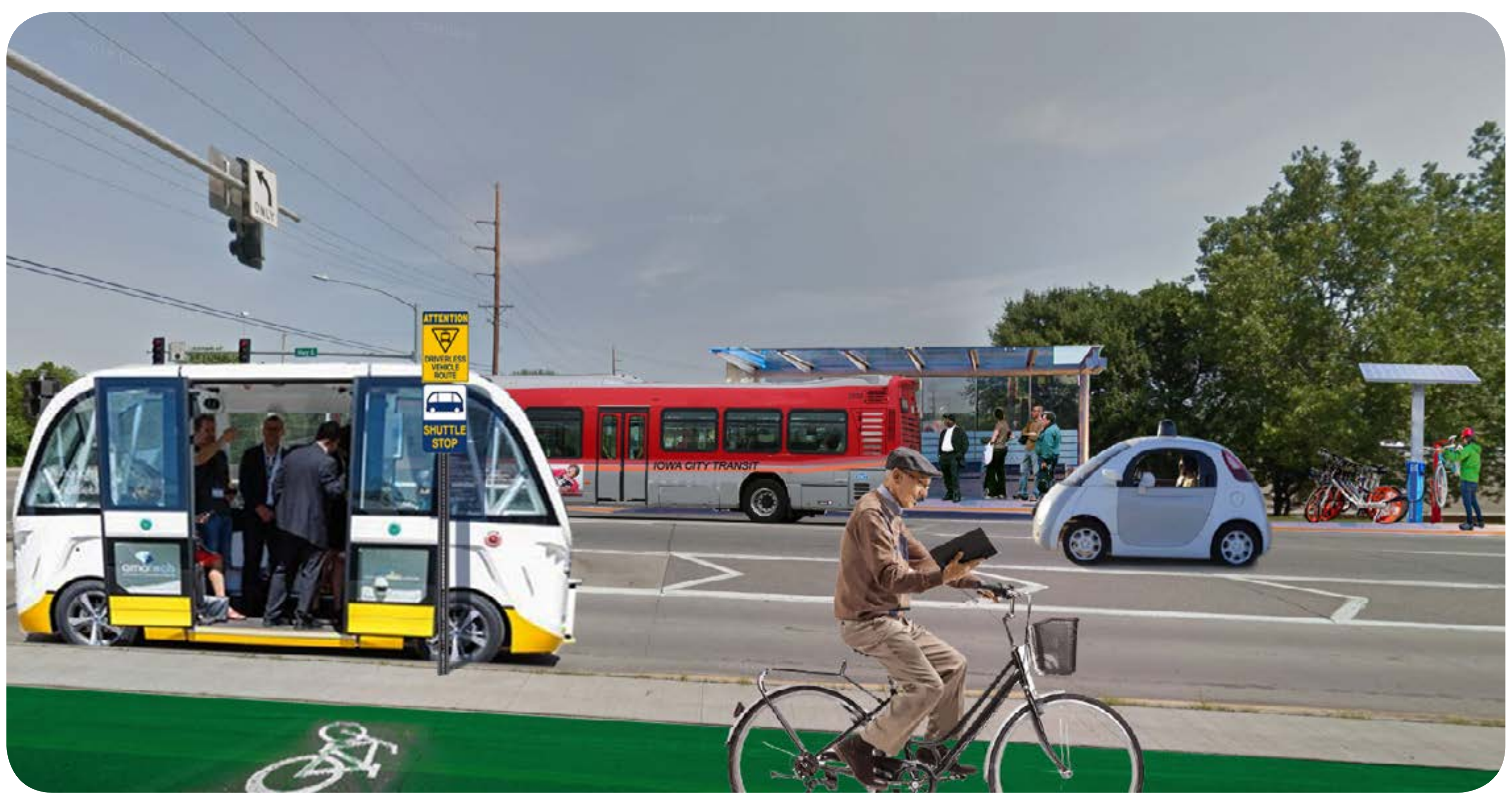


Figure 49: Integrated shared mobility and active transportation component (Source: Authors)

network for all residents while potentially mitigating the adverse impacts these companies may exert.

The public's reaction to this component is provided below:

1. The main concern for residents regarding the current use of Iowa City roads is the lack of pedestrian and bicycle infrastructure. One attendee even wrote in the desire for continuous sidewalks. Residents were least concerned with a lack of parking facilities.

2. Residents believed that the most appropriate regulations enacted by Iowa City for TNCs would be to formalize a permitting process for TNC operations and an agreement for TNCs to share data with the city.

3. Residential perception of AVs and their potential benefits and impacts on Iowa City's urban landscape showed no trend. While some attendees were excited for AVs and their prospective benefits, some did not know enough about AV technology to answer.

4. On a perceived comfort level from 1-5, with 5 meaning that the respondent would be perfectly comfortable riding as a passenger in a driverless vehicle, showed that the majority of respondents did not know enough about the technology to answer confidently.

VISION COMPONENT 4: LAND RECLAIMED FOR NEW PUBLIC & PRIVATE DEVELOPMENT

Iowa City currently allocates 12.9% (3.27 sq. mi) of its land to public roadways. While the allocation of this amount of space for transportation is necessary to maintain a safe, efficient road network, additional opportunities for public, economic and residential development are foregone. As Iowa City continues to grow and attract new residents, the pressures felt from growth will likely require significant public and private investments in open spaces, housing and a need to increase economic development opportunities. The integration of automated vehicles in Iowa City roadways could decrease demand for public right-of-way as these vehicles will likely require less space for operation and parking, opening up the door for new uses in former roadways.

The 20-year vision for Iowa City could envision a future downtown district that reserves automobile travel exclusively for high-occupancy vehicles, with full-service transit and shared mobility modes within a 5-minute or less walk. The reduction in public roadway and parking space could allow Iowa City to pursue infill development for residential uses, create new common areas for civic interaction and allow Iowa City business owners to explore creative ways to utilize downtown space for eco-

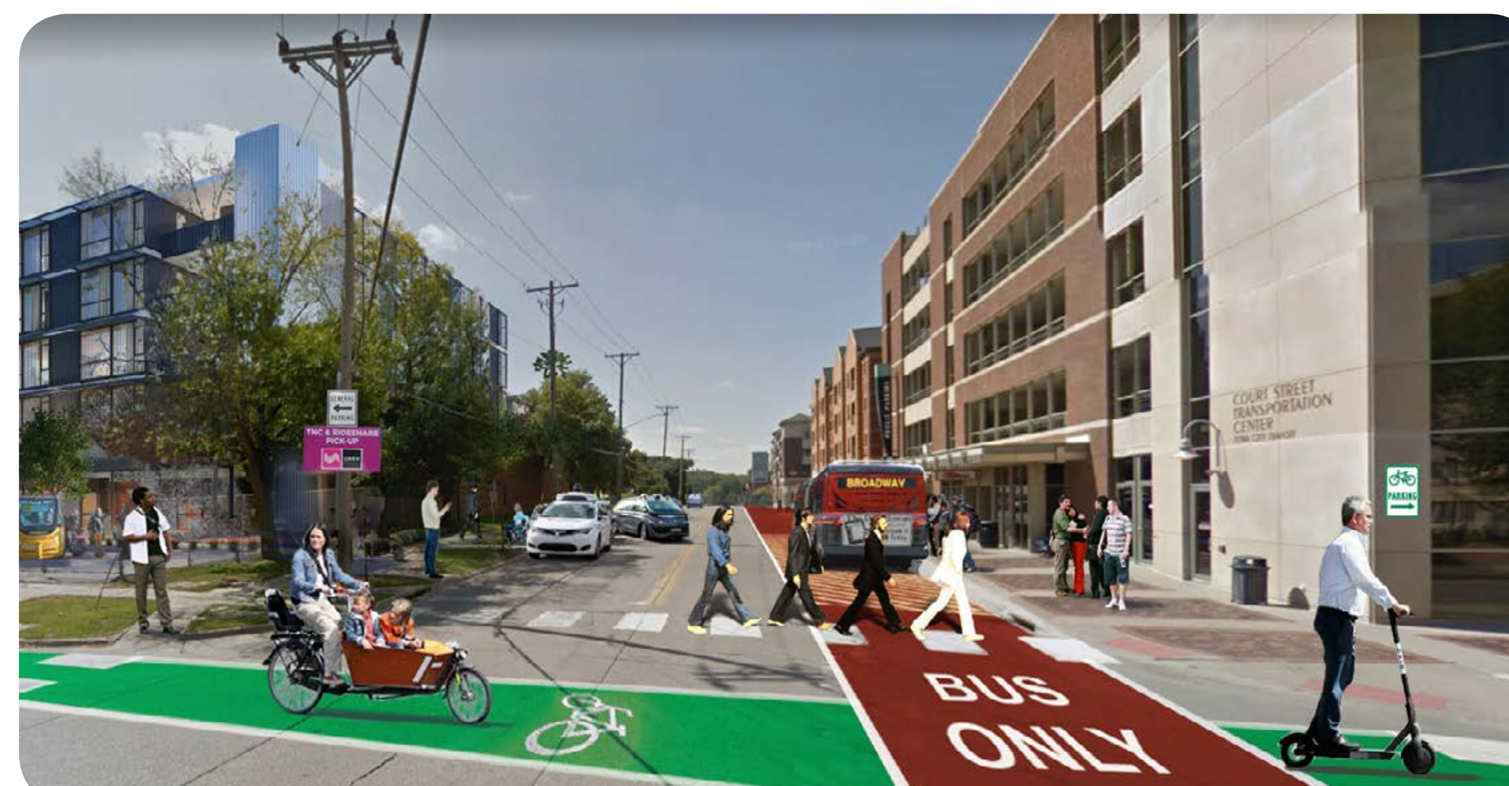


Figure 50: Transportation network companies and the community component (Source: Authors)

nomic activity.

The open house's feedback and questionnaire summary highlight the following:

1. Respondents felt that the parts of Iowa City that would be best reimagined for new commercial and residential development were neighborhoods next to the university and retail malls. Several respondents wrote in answers for a reimagining of surface parking lots and parking ramps for new residential or commercial development.

2. For the respondents to forgo the day-to-day use of a private automobile, they would first require expanded transit service and next, require expanded frequency and hours for public transit.

3. Less than half of the respondents would consider completely giving up a private automobile. Some of the hesitation recorded was due to the lack of regional connectivity.

CONCLUSIONS ON VISION

The planning team highly recommends that Iowa City engages in an ongoing public education and engagement campaign for residents and those living in surrounding areas. This can be done via the implementation of a local AV commission that also corresponds with regional and state commissions on AVs. By maintaining an open and clear channel of communication, Iowa City officials could lead the discussion about what a desirable future for all residents may entail in the context of current mobility challenges with evolving transportation technologies. Objective-based learning environments and regular educational programs are recommended for gaining a community-wide understanding of this technology as the potential for AVs becomes more apparent and increasingly relevant in the City's decision-making processes. The feedback from the open house revealed that residents of Iowa City and the surrounding areas are interested in how the Iowa City community is shaped through the transportation system. Also revealed during the open house is how mobility challenges for many of the City's disadvantaged households may be addressed with advancing technology, as well as shared AVs' potential to reduce congestion associated with private automobile use.

Commonality was found between the desires of stakeholders interviewed and the desires of the general public who attended the open house. One such commonality was

Figure 51: Land reclaimed for new public and private development component (Source: Authors)

the belief that public expenditures associated with transportation improvements should be allocated first for public transit and next for bicycle and pedestrian safety. An interest in permitting TNCs to operate in the public roadways was established in the open house but was not discussed in the stakeholder interviews. A concern over the lack of parking was expressed in stakeholder interviews, yet the general public open house responses did not seem to think there was an issue with parking availability, as it was of least concern in terms of public infrastructure investments. Lastly, most stakeholders interviewed would have paid slightly more for a service for day-to-day trips via the use of an automated driverless transit system, while many of the general open house respondents stated they would not pay more than the current fare for Iowa City transit services of $1 per trip.

Overall, this is the first public engagement opportunity conducted in Iowa City to gather interested parties in order to assess the public stance on mobility issues in a rapidly advancing transportation environment. This meeting was broadcast on every media outlet in the region and received interest from Mayor Jim Throgmorton and City Manager

Figure 53: Open house attendants (Source: Authors)

Geoff Fruin. The environment supported an unbiased and objective conversation with all who participated. Due to this, it is believed future meetings such as this would be greatly conducive toward encouraging community participation. Community meetings may also reinforce a strong sense of civic pride among all residents by opening a clear and transparent channel of communication that addresses current mobility challenges and identify strategies that mitigate future mobility issues.

Figure 52: Open house attendants (Source: UI Office of Outreach and Engagement)

A CALL TO ACTION

WHERE TO ADAPT

The Iowa City Adaptation and Equity Plan is designed to serve as a policy guidebook for City officials and decision-makers to consider and apply in future planning activities. The goals and vision articulated in the Iowa City Comprehensive Plan, District Plans, Climate Action Plan, and the Johnson County Long Range Transportation Plan serve to inspire the policy interventions recommended by the planning team. This section of the plan aims to summarize the link between recommended strategies for addressing the future integration of automated vehicles in Iowa City's future urban landscape and planning documents.

IC2030: COMPREHENSIVE PLAN UPDATE

Community Vision statement:

"Iowa City is an energetic and friendly community, renowned for its arts and culture, healthcare and education, and distinctive local businesses. The small-town character of our neighborhoods combined with the big-city vitality of our Downtown and university campus make Iowa City a unique and appealing place for people of all ages. These assets define our sense of place and are the foundation of our stable economy."

Relevant Objectives:

1. Growth and Land Use:

• Encourage compact, efficient development that is contiguous and connected to existing neighborhoods to reduce the cost of extending infrastructure and services and to preserve farmland and open space at the edge of the city.
• Maintain a strong and accessible Downtown that is pedestrian-oriented with a strong and distinctive cultural, commercial, and residential character.

2. Transportation:

• Providing safe and efficient modes of travel for all in order to ensure the opportunity for full participation in community life and efficient use of resources.
• Accommodate all modes of transportation on the street system.
• Encourage walking and bicycling.
• Promote use of public transit.
• Maximize the safety and efficiency of the transportation network.
• Encourage economic vitality through transportation innovation and investment.

Policy Interventions to assist in meeting these objectives:

1. Growth and Land Use:

• Residential Parking Permit Program for neighborhoods near the Downtown district.

• Revise zoning and subdivision regulations for residential and commercial developments to encourage the integration of shared mobility modes and related infrastructure in existing and proposed developments.
• Planning considerations for new developments—transit-supportive development, parking reductions, right of way (ROW) layout.

2. Transportation

• Implement a Pick Up and Drop Off (PUDO) management plan in downtown Iowa City for regulating public right of way in the context of transportation network companies (TNCs), paratransit operations, and commercial operations.
• Create public-private partnerships to allow shared mobility modes to complement Iowa City transit.
• Mandate levels of service for Transportation Network Companies in mobility challenged areas of Iowa City
• Rideshare Voucher Program
• Fixed-Route and Neighborhood door-to-door AV Shuttle Transit System

For Iowa City's Consideration:

• As Iowa City prepares to update its Comprehensive Plan in the near future, the planning team advises City officials to consider these elements of the plan to assist the City in achieving the goals set forth in the IC2030 Comprehensive Plan as well as formulating new goals and objectives related to future land uses and transportation improvements.

DISTRICT PLANS

The City of Iowa City has 8 completed District Plans and is planning to complete two additional District Plans in the future. The planning team recommends that City leaders and decision-makers consider the policy interventions discussed in the Iowa City Automated Vehicle Adaptation and Equity Plan in addressing the strategies contained within each district plan, especially for the Downtown and Riverfront Crossings District Plan.

For Iowa City's Consideration:

• Consider the policy interventions associated with the Growth and Land Use and Transportation sections of the IC2030 Comprehensive Plan Update in addressing the challenges specific to each district within the City.
• Engage with residents of each district to delineate the role they would like to see automated vehicles and related technologies to play in their neighborhoods.
• Apply the zoning and subdivision regulations discussed in the Iowa City Automated Vehicle Adaptation and Equity Plan to the Riverfront Crossings Form-based Zoning Code.

CLIMATE ACTION PLAN

Iowa City is a progressive and forward-thinking community that values sustainability and resiliency in planning projects. In 2016, the City authored a Climate Action Plan that seeks to reduce 2005-level greenhouse gas emissions by 26 to 28 percent by the year 2025 and 80 percent by the year 2050. The Climate Action Plan aims to achieve these goals by focusing on five areas: Buildings, Transportation, Waste, Adaptation, and Sustainable Lifestyle.

The planning team feels that the Iowa City Automated Vehicle Adaptation and Equity Plan serves as an effective guide for aiding in the reduction of transportation-related greenhouse gas emissions and helping the City reach its transportation-related greenhouse gas emissions reduction goal of 80 percent by the year 2050.

Relevant Transportation Objectives:

• By 2050, replace 55 percent of vehicle trips with sustainable transportation options, such as public transportation, bicycle, pedestrian, or clean vehicles.

Policy Interventions to meet this objective:

• Revise zoning and subdivision regulations for residential and commercial developments to encourage the integration of shared mobility modes and related infrastructure in existing and proposed developments.
• Implement a PUDO management plan in downtown Iowa City for regulating public ROW in the context of transportation network companies, paratransit operations, and commercial operations.
• Create public-private partnerships to allow shared mobility modes to complement Iowa City transit.
• Mandate levels of service for Transportation Network Companies in mobility challenged areas of Iowa City
• Rideshare Voucher Program
• Fixed-Route and Neighborhood door-to-door AV Shuttle Transit System.

For Iowa City's Consideration:

• Consider the policy interventions discussed above in future planning projects and any updates to the Climate Action Plan to ensure Iowa City is on the right track to meeting its greenhouse gas emission reduction goals related to transportation.

JOHNSON COUNTY LONG RANGE TRANSPORTATION PLAN

The Metropolitan Planning Organization of Johnson County completed its 2017-2045 Long Range Transportation Plan in 2015. This plan is in the context of the regional transportation system of Johnson County and articulates the vision and goals of relevant stakeholders and residents for the future transportation network of all communities within the county.

While the timeframe of the Iowa City Automated Vehicle Adaptation and Equity Plan is the same as the Long Range Transportation Plan, the planning team recommends that all stakeholders associated with the regional transportation system of Johnson County review the policy interventions found within the Automated Vehicle plan in order to begin the discussion of the role AVs could play in a regional context.

For Iowa City's Consideration:

• Review the policy interventions presented by the planning team and explore how these recommendations can be leveraged to foster a more efficient and equitable regional transportation network.
• Apply the policy interventions related to Iowa City transit in the upcoming Iowa City Transit route study.

BIBLIOGRAPHY

Alsnih, R. A. (2003). The Mobility and Accessibility Expectations of Seniors in an Aging Population. Transportation Research Part A: Policy and Practice, vol. 37, no. 10, 903–16.

APTA. (2016, September 7). The Hidden Traffic Safety Solution: Public Transportation. Retrieved from www.apta.com: https://www.apta.com/resources/reportsandpublications/Documents/APTA-Hidden-Traffic-Safety-Solution-Public-Transportation.pdf

American Public Transportation Association. (2008). Public transportation reduces greenhouse gases and conserves energy. Washington DC, US: American Public Transportation Association (APTA).

Arnold, M. (2018, March 6). Iowa City taking next step in regulating rentals. Retrieved from The Gazette: https://www.thegazette.com/subject/news/iowa-city-taking-next-step-in-regulating-rentals-20180306

Bagloee, Saeed Asadi, et al. "Autonomous Vehicles: Challenges, Opportunities, and Future Implications for Transportation Policies." Journal of Modern Transportation, vol. 24, no. 4, Dec. 2016, pp. 284–303. Springer Link, doi:10.1007/s40534-016-0117-3.

Bertoncello, Michele, and Dominik Wee. (2015). "Ten Ways Autonomous Driving Could Redefine the Automotive World." McKinsey & Company, McKinsey&Company Automotive&Assembly, June 2015, www.mckinsey.com/industries/automotive-and-assembly/our-insights/ten-ways-autonomous-driving-could-redefine-the-automotive-world.

Bontrager Auto Service Inc LLC v. Iowa City Board of Adjustment, 05-1064 (Supreme Court of Iowa March 7, 2008).

Bösch, Patrick M., et al. "Cost-Based Analysis of Autonomous Mobility Services." Transport Policy, vol. 64, May 2018, pp. 76–91. Crossref, doi:10.1016/j.tranpol.2017.09.005.

Boulder. (2018) Municipal Code TITLE 4 - LICENSES AND PERMITS, Chapter 23 - Neighborhood Parking Zone Permits. 4-23-2. - Permit Issuance.

Casley, S. V. (2013). A study of public acceptance of autonomous cars (Bachelor of Science). Worcester, Massachusets: Worcester Polytechnic Institute.

Cohen, Adam and Susan Shaheen. (2016). "Planning for Shared Mobility." PAS Report 593. Chicago, Illinois: American Planning Association.

Cox Automotive. (2018). Evolution of Mobility: Autonomous Vehicles. Retrieved from https://d8imphy647zzg.cloudfront.net/wp-content/uploads/2018/08/2018-Cox-Automotive-Evolution-of-Mobility-Study_Autonomous-Vehicles-Research-FINAL.pdf

Crute, J. W. (2018). Planning for Autonomous Vehicles, PAS Report 592. Chicago, Illinois: American Planning Association.

Dawid, I. (2019). It takes a Fatality to Remove Street Parking. Planetizen. Retrieved from https://www.planetizen.com/news/2019/03/103385-it-takes-fatality-remove-street-parking

Department of Planning and Community Development. (2008). Central District Plan. Iowa CIty, IA.

Dobrian, J. (2018, April 10). City Council needs to remedy parking ramp payment issue. Retrieved from Iowa City Press-Citizen: https://www.press-citizen.com/story/opinion/contributors/writers-group/2018/04/10/iowa-city-downtown-free-parking-tickets/494800002/

Erin, Stepp. "Driving Cost per Mile Archives." AAA NewsRoom, https://newsroom.aaa.com/tag/driving-cost-per-mile/. Accessed 10 Nov. 2018.

Ezike, R., J. Martin, K. Catalano, J. Cohn. (2019). Where Are Self-Driving Cars Taking Us? Pivotal Choices That Will Shape DC's Transportation Future. Union of Concerned Scientists. Washington, DC.

Fagnant, Daniel J., and Kara Kockelman. "Preparing a Nation for Autonomous Vehicles: Opportunities, Barriers and Policy Recommendations." Transportation Research Part A: Policy and Practice, vol. 77, July 2015, pp. 167–81. ScienceDirect, doi:10.1016/j.tra.2015.04.003.

Fischer-Baum, Reuben. "How Your City's Public Transit Stacks Up." FiveThirtyEight, 31 July 2014, https://fivethirtyeight.com/features/how-your-citys-public-transit-stacks-up/.

Federal Highway Administration (FHWA). (2011). FHWA Scenarion Planning Guidebook. U.S. Department of Transportation.

Federal Highway Administration (FHWA). (2017). Contemporary Approaches to Parking Pricing: A Primer. Retrieved from https://ops.fhwa.dot.gov/publications/fhwahop12026/sec_5.htm

Fort Collins. (2018). RP3 Permits. Retrieved from https://www.fcgov.com/parking/residential-parking-permit/permits.php

Governing (2018). Special Report: How Autonomous Vehicles Could Constrain City Budgets. http://www.governing.com/gov-data/gov-how-autonomous-vehicles-could-effect-city-budgets.html. Accessed 10 Nov. 2018.

Graehler Jr, M., Mucci, R. A., & Erhardt, G. D. (2019). Understanding the Recent Transit Ridership Decline in Major US Cities: Service Cuts or 1 Emerging Modes? 2 (No. 19-04931).

Hodges, T. (2010). Public transportation's role in responding to climate change. Diane Publishing.

Humphreys, J., D. Wheeler, P. Box, T. Sullivan. (1977). Safety Considerations in the Use of On-Street Parking. Transportation Research Board 722. Washington, DC.

Iowa City. (1994). Municipal Code, TItle 9 - Motor Vehicle and Traffic, Chapter 4: Parking Regulations, 9-4-10: Parking for Loading and Unloading. Iowa City, Iowa.

Iowa City. (1994). Municipal Code, TItle 9 - Motor Vehicle and Traffic, Chapter 4: Parking Regulations, 9-4-3: Parking no to obstruct traffic. Iowa City, Iowa.

Iowa City. (2013). Iowa City 2030. Iowa City, IA.

Iowa City. (2015). Complete Streets Policy. Iowa City, IA.

Iowa City. (2016). Riverfront Crossings and Eastside Mixed Use District Form-Based Development Standards. IA: Iowa City, 84

Iowa City. (2018). Climate Action And Adaptation Plan. Iowa City, IA.

Iowa Department of Management. (2019). Adopted City Budget Documents, Form 631 B. Retrieved from https://dom.iowa.gov

Iowa Department of Transportation (DoT). (2018). Iowa DOT Saver, Iowa DOT, icat.iowadot.gov/.

Iowa Department of Transportation (DoT) (2016) MAPS VEHICLE-MILES TRAVELED (VMT). Retrieved from https://iowadot.gov/maps/Data/Vehicle-miles-traveled

Institute for Local Government, (2015). Retrieved from https://www.ca-ilg.org/sites/main/files/file-attachments/1._ilg_what_is_public_engagement_and_why_should_i_do_it_mar_2015.pdf

Institute of Transportation Engineers (ITE). (2016). Transportation Planning Handbook, 4th Edition, Edited by Meyer, M. D. Wiley

Johnson County Council of Governments . (2009). Metropolitan Bicycle Master Plan . Iowa City, IA.

Johnson County MPO. (2012). Long Range Transportaion Plan 2012-2040. Iowa City, IA.

Johnson County MPO (2018). FY2017 Performance Statistics. Iowa City, IA. Accessed 17 Sep. 2018.

KPMG. (2013). Self-Driving Cars: Are We Ready? . Retrieved from https://home.kpmg.com/content/dam/kpmg/pdf/2013/10/self-driving-cars-are-we-ready.pdf

Labelle, J. C. (2016). Exploring the Potential for Off Peak Delivery in Metropolitan Chicago: Research Findings and Conclusions. Chicago, Illinois: The Urban Transportation Center at the University of Illinois at Chicago.

LA Metro. (2019a). Transti-Oriented Development Toolkit: Incentives and Bonuses. LA Metro. Retrieved from https://www.metro.net/projects/tod-toolkit/incentives-bonuses/

LA Metro. (2019b). Transti-Oriented Development Toolkit: Site Layout, Parking Layout, and Building Design. LA Metro. Retrieved from https://www.metro.net/projects/tod-toolkit/site-layout-parking-layout-and-building-design/

Levine, J., Zellner, M., Shiftan, Y., de Alarcon, M. A., & Diffenderfer, A. (2013). Effects of Automated Transit, Pedestrian, and Bicycling Facilities on Urban Travel Patterns, 260. US Department of Transportation. https://taubmancollege.umich.edu/sites/default/files/files/effects-of-automated-transit-pedestrian-and-bicyling-facilities-on-urban-travel-patterns.pdf

Litman, T. (2017). Reduced and More Accurate Parking Requirements. Planetizen. Retrieved from https://www.planetizen.com/node/92360/reduced-and-more-accurate-parking-requirements

Litman, T. (2017). Autonomous Vehicle Implementation Predictions. Implications for Transport Planning. Victoria Transport Policy Institute, 27 February 2017//[Electronic resource].

Litman, T. (2002). Evaluating transportation equity. World Transport Policy & Practice 8.2 (2002): 50-65.

Litman, T. (2004). Transit price elasticities and cross-elasticities. Journal of Public Transportation, 7(2), 3. http://doi.org/10.5038/2375-0901.7.2.3

Lu, Z., Du, R., Dunham-Jones, E., Park, H., & Crittenden, J. (2017). Data-enabled public preferences inform integration of autonomous vehicles with transit-oriented development in Atlanta. Cities, 63, 118–127. https://doi.org/10.1016/j.cities.2017.01.004

Mcity. (2018). Mcity Driverless Shuttle, A case study. University of Michigan. Ann Arbor, MI

McMahon, J. (2018). How Car Sharing Can Save The World from The Autonomous-Vehicle Robot Apocalypse. Forbes. Retrieved from https://www.forbes.com/sites/jeffmcmahon/2018/03/18/how-car-sharing-companies-can-save-the-world-from-the-autonomous-vehicle-robot-apocalypse/#317329694fab

Mims, S. (2018, June 19). Iowa City Council's Core Four seems to be moving goal posts of downtown development. Retrieved from Iowa City Press-Citizen: https://www.press-citizen.com/story/opinion/contributors/guest-editorials/2018/06/19/future-development-iowa-citys-riverfront-crossings-uncertain/706498002/

Morelli, B. A. "Cities in the Corridor Look to Keep Momentum as Public Transit Grows." The Gazette, https://www.thegazette.com/subject/news/cities-in-the-corridor-look-to-keep-momentum-as-public-transit-grows-20140618. Accessed 10 Nov. 2018.

National Association of City Transportation Officials (NACTO). (2017). Blueprint for Autonomous Urbanism. NY: New York

Nguyen, A. (2019). San Diego City Council Votes to Repeal Minimum Parking Requirements for New Housing. Times of San Diego. Retrieved from https://timesofsandiego.com/politics/2019/03/04/san-diego-city-council-votes-to-repeal-minimum-parking-requirements-for-new-housing/

NHTSA. (2015). Critical Reasons for Crashes Investigated in the National Motor Vehicle Crash Causation Survey. Washington, D.C.: USDOT. Retrieved 10 21, 2018, from https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812115

NHTSA. (2018, 10 17). Automated Vehicles for Safety. Retrieved 10 21, 2018, from NHTSA: https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety#issue-road-self-driving

Nielsen, T. A. (2018). On sceptics and enthusiasts: What are the expectations towards self-driving cars? Transport Policy 66, 49-55.

Nisenson, L. (2018). Best Case Scenario Planning. The Magazine of the American Planning Association, 16-21.

Parzen, Julia. (2015). "Shared-Use Mobility Reference Guide." Chicago, Illinois: Shared Use Mobility Center.

Power, J. D. (2012). 2012 U.S. Automotive emerging technologies study results. Retrieved from http://autos.jdpower.com/content/press-release/gGOwCnW/2012-u-sautomotive-emerging-technologies-study.htm

Power, J. D. (2013). 2013 U.S. automotive emerging technologies study results. Retrieved from http://autos.jdpower.com/content/study-auto/f85EfAp/2013-u-sautomotive-emerging-technologies-study-results.htm

Quarles, Neil, and Kara M. Kockelman. Costs and Benefits of Electrifying and Automating US Bus Fleets. No. 18-00259. 2018.

RSG. (2016). Burlington residential parking management plan. Retrieved from https://www.burlingtonvt.gov/sites/default/files/DPW/Publications/ResidentialParkingPlan_final.pdf

San Francisco Transportation Board. (2009). On-Street Parking Management and Pricing Study. San Francisco.

Scharnhorst, E. (2018). Quantified Parking: Comprehensive Parking Inventories for Five U.S. Cities. Research Institute for Housing America.

Schmidt, M. (2015, September 3). Iowa City commission weighs development of downtown parking lots. Retrieved from The Gazette: https://www.thegazette.com/subject/news/government/iowa-city-council-weighs-development-of-downtown-parking-lots-20150903

Schmitt, A. (2018). Minneapolis Moves to Eliminate Mandatory Parking. Streetsblog. Retrieved from https://usa.streetsblog.org/2018/12/12/minneapolis-moves-to-eliminate-mandatory-parking/

Schwartz, P. (1996). The Art of the Long View: Planning for the Future in an Uncertain World. Doubleday.

Senstad, J. (2016, December 7). City heads for parking study near downtown. Retrieved from The Daily Iowan: https://dailyiowan.com/2016/12/07/city-heads-for-parking-study-near-downtown/

Shaheen, Susan and Nelson Chan. (2015). "Shared Mobility- Definitions, Industry Developments, and Early Understanding." Berkley, California: Transportation Sustainability Research Center.

Shoup, D. (2005). The Highg Cost of Free Parking. Chicago, IL: American Planning Association.

Shoup, D. (2018). Parking and the City. Planner's Press, Routledge.

Sivak, M. (2016). Recent Decreases in the Proportion of Persons with a Driver's License across All Age Groups. Ann Arbor: Transportation Research Institute Report, UMTRI-2016-4, University of Michigan.

Sivak, Michael, and Brandon Schoettle. "Potential Impact of Self-Driving Vehicles on Household Vehicle Demand and Usage." Sustainable Worldwide Transportation Program (www. umich. edu/~ umtriswt), University of Michigan (2015).

Skip, Descant. Could Autonomous Vehicles Add to Congestion? Maybe, Say Planners. http://www.govtech.com/fs/automation/Could-Autonomous-Vehicles-Add-to-Congestion-Maybe-Say-Planners.html. Accessed 10 Nov. 2018.

SRF Consulting. (2018). Parking & Transportation Management Authority (TMA) Study Report. Rochester, MN.

Stantec. (2018). Chamblee Self-Driving Shuttle Feasibility Study and Concept Plan. City of Chamblee, GA.

Steuteville, R. (2016). Green Code will help Buffalo to grow again. Public Square, CNU Jorna. Retrieved from https://www.cnu.org/publicsquare/2016/12/28/green-code-will-help-buffalo-grow-again

U.S. Department of Transportation. (2016, August 30). Traffic Fatalities Up Sharply in 2015. Retrieved 10 21, 2018, from www.transportation.gov: https://www.transportation.gov/briefing-room/traffic-fatalities-sharply-2015

U.S. Department of Transportation. (2018). USDOT Automated Vehicles 3.0 Activities, United States Department of Transportation, 27 Sept. 2018, www.transportation.gov/av/3.

U.S. EPA. "Smart Location Mapping." US EPA, 27 Feb. 2014, https://www.epa.gov/smartgrowth/smart-location-mapping.

Wheelwright, T. (2018, 8 27). Best College Towns in Your State. Retrieved from Reviews.org: https://www.reviews.org/trends/best-college-towns/

Youngs, J. (2014). 2014 U.S. Automotive emerging technologies study results. Retrieved from http://autos.jdpower.com/content/study-auto/lN3SbRs/2014-u-s-automotive-emerging-technologies-study-results.htm

Zhanga, W. S. (2015). Exploring the impact of shared autonomous vehicles on urban parking demand: Anagent-based simulation approach. Sustainable Cities and Society Volume 19, 34-45.

WSB & Associates, Inc. and AECOM. (2018). MnDOT Autonomous Bus Pilot Project Testing and Demonstration Summary. Report. Minnesota Department of Transportation Research Services & Library

APPENDICES

A.1 TRANSIT STUDY METHODOLOGY

The transit study used a locational analysis method based on data collected from several sources. For the locational analysis and map creation, the transit study used the Geographic Information System (GIS) platform, ArcMap. The first step of the locational analysis was to obtain the necessary demographic, socio-economic, and travel pattern data at the block group level, which was collected from the ACS 2012-2016 of the U.S. Census Bureau. Next, this data was entered into ArcMap to create several maps of Iowa City and illustrate the block group level demographic, socio-economic, and travel pattern information. The specific socio-economic data used were percentage of low wage workers per block group and percentage of households owning zero cars, one car and two or more cars. For the travel pattern analysis, the transit study used percentage of people who use public transit for work trips and percentage of people not served by the current transit schedule. Additionally, the transit service frequency data for each stop was collected from the City of Iowa City. The transit boarding data was compiled from a 2-week survey conducted during April 2018. This 2-week boarding data was converted into a measure of daily boarding rates by summing and averaging the data for that period. Also, for the transit service frequency, the authors calculated the frequency with which Iowa City transit buses recorded stops at each transit stop location for each day of the City of Iowa City data. Finally, with the use of ArcMap, the boarding and service frequency data were assigned to each stop and then displayed in relation to the specified demographic data. After the analysis was conducted, it was found that 418 transit stops are served by the City buses in different block groups of Iowa City.

For the transit accessibility study, the stop location data of the Iowa City transit system was collected from the City of Iowa City; applying the 0.25-mile buffer around each stop, the service area of the Iowa City transit system was delineated. This service area determination was done using the ArcGIS Network Analyst toolset. The rationale for using the network analyst tool is that it uses the links and nodes associated with the City street network data to create the road network used in the analysis. The road network then becomes the travel path individuals take when accessing the stops, which are then overlaid on the road network created by the network analyst tool. This road network dataset was prepared over several steps and used road length as an impendence value as the study was mainly concerned with the distance from the transit stops; the impedance value serves as cut-off point, at which any distance traveled beyond the impedance value people will go to that bus stop. Next, using the service area option of the network analyst tool and the 418 stops currently served by Iowa City Transit as well as the 0.25 radius surrounding each stop, the initial service area of the Iowa City Transit System was determined.

A.2 VOUCHER PROGRAM CALCULATION

For the voucher program design, the first step was to calculate the total cost of providing vouchers to Iowa City residents. The calculation of the total cost was done in two steps. At the initial step, the total number of people in each block group not served by the current transit schedule was calculated using block group level data collected from the ACS 2012-2016. A second dataset for the percentage of Iowa City households who did not own a personal vehicle was collected from the Environmental Protection Agency (EPA) smart dataset. This percentage value was used as a proxy for people who do not have any options for commuting to work. Then this percentage value was multiplied with the total number of off-time workers to estimate the total number of people who are eligible for the voucher in a block group. For example, if a block group has 100 people with off-time jobs and 10 percent of people have zero cars, the estimated eligible number of people on that block group will be 10. In this process, 1067 eligible person for the voucher from different block group of Iowa City was calculated. It was assumed that the maximum voucher for each trip will be $5, and a person will be eligible for taking 5 trips in a week. Therefore, the maximum per person voucher amount per week will be $25. Based on this $25 per person cost and 1067 eligible persons voucher, a total yearly cost of $1.39 million was calculated for the voucher program. However, the City can adjust these criteria based on their budget for the voucher program.

A.3 TRANSIT SERVICE AREA CALCULATION

While building the second scenario with automated shuttles integrated into the transit system, some relevant literature review was conducted. One research publication on the incorporation of the automated vehicle into the transit system found that it can expand the transit stop service area from 0.25 miles to 2 miles (Lu, Du, Jones, Park, and Crittenden, 2017). A second study explored the use of automated driverless transit vehicles integrated with the existing transit vehicles of the system in their analysis to solve the first and last mile problems of the transit system (Levine, Zellner, Shiftan, Alarcon, Diffenderfer, 2013). Based on the results of these studies and the consideration of both of these issues at the next level, the future transit area of the Iowa City Transit was determined. In this new scenario, the transit service area becomes 15.68 square miles. It was also found that previously fixed-routes buses were operating on different fixed-routes, totaling 167 miles. With the introduction of the new automated driverless transit shuttles, the potential service area expands to 243 miles of road and includes both the main arterial roads and the neighborhood roads currently not served by transit. These lengths were calculated using the select by location tool in ArcGIS and used data from the urban road database, transit fixed-route data prepared by the author, and the two calculated service areas. In conclusion, this analysis has found that significant improvement is possible with the incorporation of automated vehicles in the transit system of the city and these improvements can bring transit services to the doorstep of residents.

A.4 PARKING STUDY METHODOLOGY

For the purpose of this report, the team supplemented the data on parking spaces provided by Iowa City with additional mapping activities that utilized ArcGIS software, Google Street View and targeted site visits in order to develop a full understanding of the existing supply of controlled-access parking (metered or requiring a special permit) citywide and total parking supply in the downtown district of Iowa City. This understanding covered all types of ownership – municipal, university, commercial and residential. The planning team also conducted an occupancy study for the identified neighborhoods that bear the pressure of spillover parking from the downtown district to evaluate the feasibility of a residential parking permit program as pursuant to the Iowa City planning documents reviewed above. Finally, we discuss the areas of the city that experience transportation challenges due to the high intensity of commercial and recreational activities identified while conducting the inventory and parking studies.

Once the data was gathered, the planning team calculated the density of parking spaces in the Iowa City downtown district using the methodology of a report published in summer of 2018 that supports the development of an enormous amount of space dedicated to parking in five American cities: New York, Seattle, Des Moines, Jackson and Philadelphia (Scharnhorst, 2018). Following this approach, the team created a hexagonal grid that covers all of the downtown district. The team choose hexagons due to their ability to be tessellated edge-to-edge over the area. This sampling technique is often used in environmental studies to define sampling locations for the area. To produce the hexagonal grid, the team used a script that creates a mesh of point spaced in a way that allows ArcGIS's Create Thiessen Polygons tool to generate equal side length hexagons (side length of each hexagon is 128 foot, to get the area equal to 1 acre). At the next step, the mesh is intersected with the study area (which is the border of Iowa City downtown district) to create the final hexagon grid. The data is visualized as average parking density per hexagon to illustrate the overall density of parking spaces per acre.

For the occupancy study the team selected a sample from two neighborhoods that abut metered parking zones of Iowa City's downtown district, borrowing an approach to a residential parking permit area extension study employed in San Francisco (San Francisco Transportation Board, 2009). Each sample comprises 10 blocks, for which an estimate of existing parking supply in the public right-of-way is calculated, subtracting the spaces that are metered, and retaining the side of the road that has an odd/even parking sign on display. Cars were counted and plate numbers were recorded twice for each area, with the initial time being between 10 PM and 11 PM in the evening to capture the assumed residential demand for on-street parking. The second car count occurred the next day, between 10 AM and 11 AM, to evaluate parking occupancies and estimate the number of cars that park in these neighborhoods permanently by referring to the recorded car plates from the day before. The exercise was conducted during week days, with consideration of Iowa City's celebrations and holidays, in order to omit the potential impact of such events. The recorded counts were later analyzed for each two-block section and averaged for each sample.

A.5 PUBLIC INPUT METHODOLOGY

According to the Institute of Local Government, the importance of public engagement can be seen in the resulting civic pride and community trust-building that follows public engagement activities that are done inclusively and effectively. One potential aspect of inclusive public participation is that it can identify the diverse values of residents and uncover valuable ideas from within the community. Residents may become more informed about challenges through an educational and public engagement process and, thereby, offer recommendations that can guide the City toward shaping a more desirable environment in which to live. This process can lead to better decision making and lead to positive impacts and better outcomes. The actions of City leaders may also be met with more support and buy-in from the residents. This kind of support could lead to faster implementation of projects with less pushback. Greater participation from the community has been studied to encourage greater trust in a city's decision-making activities. Inclusive participation also leads to greater trust in each other as neighbors (Institute for Local Government, 2015).

The team identified stakeholders who represented a population group or a special expertise sensitive to emerging transportation technologies. The stakeholders are representatives of a variety of fields including the metropolitan planning organization, freight operators, bicycle advocates, students, individuals with disabilities or language barriers dependent on transit, the business community, transit users, neighborhood outreach, parking and transportation for the University of Iowa, individuals experiencing homelessness, and more.

The team has met with individual stakeholders with the expectation they are an expert in their field. An unbiased and uninfluenced conversation takes place with two topics and four sections. The topics are about the current state of the transportation networks as well as the individual stakeholder's knowledge and opinions pertaining to automated and driverless vehicles. The stakeholder discussion involved four topic sections each including five to six questions. The sections covered are: current habits and challenges, familiarity with automated vehicles, pros and cons of automated vehicles, and the propensity to use automated vehicles (see Appendix A.11).

Conversations with stakeholders involved four topics. Each topic consisted of four to five opinion-based questions, while no supplemental information regarding automated vehicles was provided before or during the interview. The planning team's intent in not providing supplemental information was to reduce the chance of biases in stakeholder responses and encourage the interviewees to speak on the topics to the best of their knowledge.

The first series of questions was on the topic of current habits and challenges related to residential travel in Iowa City. These questions sought to understand the participants' opinion of travel habits of commuter and leisure passengers, including private, rideshare, and transit trips. The participant was also asked about overall concerns with mobility and accessibility in Iowa City's transportation system. The second series of questions sought to reveal the participants' familiarity with automated vehicles, specifically, if the individual was familiar with automated vehicle technology and what their general opinion was on automated and driverless vehicles. This was important in gauging the stakeholder's initial understanding of the prevalence of this technology and their perception of technological advancements in automated vehicles given the time of the discussion. Following this series of questions were several questions regarding the potential impacts and benefits of driverless automated vehicles; specifically, what concerns with driverless vehicles did each participant have, and what concerns about different possible implementations of driverless vehicles in public roadways (i.e. private versus publicly owned fleets) could the participant foresee. The final series of questions sought to understand the participant's propensity to use a driverless automated vehicle, their interest in owning and automated vehicle, and their willingness to pay for driverless vehicle technology.

The first automated vehicle public open house was held in the public library in the downtown district of Iowa City from 4:30 in the afternoon until 8:30. The City, the university, and other groups aided the planning team in marketing the event to their constituents. Displayed at the open house were four possible scenarios of which the project team drew from extensive research and literature review in conjunction with the input from community experts. These four scenarios coalesce to form a long-term vision for a future with enhanced vehicle technology and served as a contrast to the baseline scenarios of "business as usual" based on current technologies and trends in Iowa City's transportation system. Paired with each scenario was a print survey that sought attendee feedback through questions related to each scenario and the policy interventions residents desire to see to realize the vision presented to them. Each survey submission was anonymously recorded. The surveys represent a broad range of interests which may be important to the community; for the full questionnaire, see the appendix.

After the public open house, the surveys and posters were digitized and circulated online for another round of feedback for the interested parties who were unable to make the in-person meeting. This online survey was open to the public for two weeks.

The open house attracted approximately 40 attendees from varying demographics and locations in and out of the City, and roughly half of the attendees submitted surveys. Each survey represented a specific scenario with generalized questions that delved into major topic areas of the plan: TNCs and the community; reclaimed land for public or private use; shared mobility and active transportation; and fixed route door-to-door automated transit. The respondents were asked about a variety of preferences, perceptions, habits, and potential to alter current habits.

Name	H.R. 3416	H.R. 3388	S 1885
Date Introduced	7/26/2017	7/25/2017	9/28/2017
Purpose	Establish NHTSA Rural and Mountainous Advisory Council for guiding testing of AVs in rural and remote areas; defines "highly automated vehicle"	Establishes role of federal government in regulating safety of AVs; preempts states from regulating design, construction, or performance of AVs	Establishes role of federal government in regulating safety of AVs; preempts states from creating legislation governing AVs; asserts conditions for testing AVs in interstate commerce
Status	Referred to Subcommittee on Health (7/28/2017)	Passed House of Representatives (9/6/2017)	Reported to Senate with amendments (11/28/2017)

Table A.1: AV legislation summary

A.6 FEDERAL LAW FOR AV

While localities around the nation are beginning to consider the role automated vehicles will play in their future urban landscape, the federal government has been proactive in drafting legislation aimed at increasing the development of this technology. Several different bodies have authored policy framework relating to AVs, including the United States Congress and the NHTSA.

Two separate pieces of legislation are being considered in Congress, with the bill HR 3388 SELF DRIVE Act having passed the House in September 2017 and the S 1885 AV Start Act that was introduced to the Senate in November of 2017. Both of these pieces of legislation are concerned with regulating safety matters associated with AVs, including performance, testing, and cybersecurity. A second major implication of both pieces of legislation is that they preempt states from regulating the design, construction, or performance of automated vehicles; the purpose of this preemption is to prevent states from establishing their own standards for AVs that could conflict with federal or other states' legislation and thus slow the development and deployment of this technology.

NHTSA, in conjunction with the US DOT, first drafted policy pertaining to AVs in September 2016 with the issuance of the Federal Automated Vehicle Policy guide. This publication was focused predominately on the safety issues related to AVs but also incorporated guidance for the deployment of AVs and state regulations for the technology; an update to the policy, A Vision for Safety 2.0, was released in September 2017. A bill introduced in the House of Representatives in July 2017, H.R. 3416 To establish in the National Highway Traffic Safety Administration a Rural and Mountainous Advisory Council, makes recommendations regarding the testing and deployment of highly automated vehicles and automated driving systems in areas that are rural, remote, mountainous, insular, or unmapped" (H.R.3416 — 115th Congress (2017-2018). This bill defines a "highly automated vehicle" as "a motor vehicle (excluding a commercial motor vehicle) equipped with an automated driving system". In this piece of legislation, NTHSA is directed to establish the Highly Automated Vehicle Advisory, which would be charged with the responsibility of evaluating the impacts of the AV on employment, the environment, cybersecurity, the mobility access of senior citizen and persons with disabilities.

A.7 ECONOMIC IMPACT OF AV ON TRUCKING IN IOWA CITY

Becoming a hot topic over the past two years, autonomous vehicles provoke a lot of creative and, occasionally, educated thinking in terms of the potential benefits and impacts. Though the full deployment of the technology will not be seen for decades, one particular industry is closer to it than the rest - freight operations (Crute, 2018). The potential gains to the industry are likely to be seen with regard to more efficient operations; a reduction in operational expenditures can enable capital investments that will shift the technological state of AVs from prototypes to market-ready vehicles. However, the loss of employment within the industry has been a subject of unsubstantiated statements that lack data driven analysis. The purpose of this section is to assess the economic impact of the loss of half of all trucking jobs in the Iowa City metro area in 2040, which is the year researchers anticipate on seeing 50% of vehicles on the road being AV. The analysis was conducted using industry data from the Bureau of Labor Statistics (BLS) and multipliers from the Input-Output model (Johnson County 2018 RIMS II Multipliers) and all dollar amounts are indexed to 2017 values.

Figure A.1 summarizes industry data from the American Community Survey (ACS) 2016 5-year Estimates; Transportation & Warehousing account for only 2.7% of total employment in the Iowa City metro. Getting

Figure A.1: Iowa City MSA employment (Source: datausa.io)

down to the trucking industry, BLS recorded 3410 Heavy and Tractor-Trailer Truck Drivers employed in the area in 2017, with a mean annual wage of $43,680. Surprisingly, this wage was 9.6% lower than the area's mean annual wage across all industries. According to BEA, the truck transportation industry produced $290 million of area's GDP, which was around 2.85% of total Iowa City metro GDP ($10,192 million) for the year 2017.

To better understand the importance of trucking industry for the Iowa City metropolitan statistical area (MSA), an Input-Output analysis was performed. This economic technique quantitively represents the interconnections between different sectors of the regional economy. It allows for the estimations of the total economic contributions of a specific enterprise or industry in terms of its direct contribution, meaning the economic values obtained from the survey and operational output; indirect activities that account for all the supplies that it consumes regionally in its production process, like banking, wholesale goods, etc.; and induced activities, those that include spending of earnings by workers employed in the trucking industry and in the regional supply sector. The results are displayed in the form of a table, where total industrial output represents the full value of the industries; value added includes workers' income, income from properties and investments as well as indirect tax payments (value added is synonymous with regional Gross Domestic Product); labor income is the sum of wages paid to workers as well as proprietors' incomes and lastly, the number of jobs that the model estimates as an annualized value based on

	Jobs	Income	Output
Direct Effects	3,410.00	207.35	590.03
Indirect Effects	1,046.40	51.98	150.35
Induced Effects	1,015.72	34.93	120.32
Total Effects	5,472.11	294.26	860.71
Multiplier (Type II)	1.6047	1.4192	1.4587

Table A.2: Trucking industry total economic effect

the industrial output even if the activity happened over a short period of time.

As table A.2 shows, the method assumes that 3410 drivers account for $590.03 million of annual output in the regional economy and these drivers received $207.35 million in labor income. The industry requires $150.35 million in regionally supplied inputs, yielding another 1,046.4 jobs with the income of $51.98 million to support the linkages between these industries. When all the drivers and supply workers start spending their paychecks, they induce another $120.32 million in regional output, supporting 1,015.72 more jobs earning $34.93 million. Overall, this means that apart from direct jobs, $590.03 million of output in trucking transportation generates an additional $270.67 million of output in the economy and supports 2,062.12 additional jobs earning $86.91 million. This also means that the total output of the industry is $860.71 million.

Researchers predict that 50% of the vehicles on the road will be driverless by the year 2040, resulting in significant impacts on the trucking industry. Based on BLS numbers and employment data, a reduction of 1,705 drivers would result in a loss of $103.67 million in direct income. Since the industry will still require energy, maintenance and other new production inputs, it is expected that the indirect sector and thus indirect output will remain robust. Moreover, since all those potential drivers facing layoffs are full time employees, they may be eligible for governmental assistance in the form of unemployment benefits and supplemental nutrition assistance programs (SNAP Food Benefits) once they are out of work. For the purpose of this exercise, it is assumed that all of these job holders are eligible to receive up to one third of their previous income for one year, $14,560 annually plus $353 per month in SNAP benefits (the maximum for a two-person household) based on the average size of a household in Johnson County being 2.2 people. Altogether, the result is an additional $32.1 million that can be added to induced output for the trucking industry that has lost 50% of its employment to an autonomous fleet. This means that the total output (at least for the first year, when governmental relief may be available) might fall by only $71.57 million in lost income plus the decrease in induced effects due to lower spending by former drivers.

As the analysis shows, despite accounting only for 2.8% of the Iowa City metro's GDP, the trucking industry yields almost 1.5 times larger total output, once we include all the inputs it requires from the region and the spending that its employees, as well as suppliers' workers, engage in. Since the industry will still need all the regional inputs, the layoff of half of the drivers will have an economic impact limited to the loss of trucking jobs and their income. One must also include governmental assistance in the estimates, as during the year that it will be available, some people will be able to complete additional training and find other jobs or gain employment elsewhere, which means it is highly unlikely that the regional economy will bear the full result of that unemployment at any time. On the other hand, this does not imply that policy makers should neglect implementing any preventive measures since the exponential rate of technological progress may lead to reductions in employment starting earlier than 2040. Once the replacement of traditional highway freight trucks begins, it probably will not stop until the whole industry is operated without the need of human drivers.

A.8 IOWA CITY DEMOGRAPHICS

According to the ACS, the estimated population of Iowa City is 75,798. The median household income is $42,720 (2016 dollars) which is lower than the average median household income of United States of $55,322. Regarding socioeconomic conditions, 28% of the Iowa City residents live in poverty. The density of population is 2,713 person per square mile. About 78.8% Iowa City residents are white, 8.2% are Asian, 7% are Black, and 5.9 % are Hispanic.

The current number of employments in Iowa City is 40,582, which grew from 2015 employment of 40,247. The unemployment rate 4.2%, however, 94.9% of the City resident with more than 25 years of age at least holds a high school degree. Also, 59.9% of the City residents with more than 25 years of age holds at least a bachelor's degree.

A.9 VEHICLE OWNERSHIP & USE

Vehicle ownership trends between 2000 and 2016 in Iowa City are significantly different from the nation's as the vehicle ownership rates declined in Iowa City by 1% compared to a 5% growth in the nation as a whole over this 16-year period. However, Johnson County saw an increase in vehicle ownership by 1%, aligning closer to the State of Iowa's growth of 3%.

Being a vibrant college town, any analysis of Iowa City would be incomplete without the consideration of its student population. As data shows, despite the 6% increase in student enrollment at the University of Iowa between 2006-2015, there was a 45% decline in the issuance of student car permits which are necessary for the vehicles to be parked on campus. During this same period the number of permits for mopeds and motorcycles more than doubled.

A.10 IOWA CITY TRAVEL PATTERNS

Travel patterns in Iowa City revolve predominately around automobile travel. According to ACS 2012-2016 5-year estimates, the most common transportation mode utilized for commuting was driving a single occupant private automobile, of which 56.7% of Iowa City commuters relied on. Other modes of commuting were walking

	Home Location	Vehicles	Occupied Households	Vehicles/Households
2016	Total U.S.	208,411,805	117,716,237	1.77
	State of Iowa	2,424,993	1,242,641	1.95
	Johnson County	99,750	56,543	1.76
	Iowa City	46,095	29,571	1.56
2000	Total U.S.	178,344,236	105,480,101	1.69
	State of Iowa	2,179,269	1,149,276	1.90
	Johnson County	77,051	44,080	1.75
	Iowa City	39,838	25,202	1.58
CHANGE '00-'16	Total U.S.	17%	12%	5%
	State of Iowa	11%	8%	3%
	Johnson County	29%	28%	1%
	Iowa City	16%	17%	-1%

Sources: 2000 Census, 2015 ACS 5-Year Estimate. U.S. Census Bureau.

Table A.3: Vehicle ownership 2000-2016

	Type of Permit	Quantity	UI Enrollment	Quantity/Students
2015	UI Permits for student cars	3350	31387	0.11
	UI Permits for Mopeds & Motorcycles	827	X	X
	City Permits for Mopeds & Motorcycles	683	X	X
2006	UI Permits for student cars	5800	29642	0.2
	UI Permits for Mopeds & Motorcycles	400	X	X
	City Permits for Mopeds & Motorcycles	X	X	X
CH. '06-'15	UI Permits for student cars	-42%	6%	-45%
	UI Permits for Mopeds & Motorcycles	107%	X	X
	Total U.S.	17%	12%	5%

Sources: UI Department of Parking and Transportation, the Parking Division of the Iowa City Transportation Services Department

Table A.4: Student vehicle permits 2006-2015

(16.3%), use of public transit (9.4%), carpooling (8.6%), bicycling (3.3%), and use of a motorcycle (0.6%). The average commute time was 15.9 minutes, which is lower than the average commute time for U.S. workers overall. However, 0.78% of Iowa City residents experienced a super commute time which is defined as a commute taking more than 90 minutes. The largest share of Iowa City households (40.9%) owned 2 cars, followed by 31.7% of households owning 1 car, and 16.1% of households owning 3 cars. However, 5.3% of households did not own a car. Due to Iowa City's nature as a college town, a significant portion of the city's population are students whom depend on the transit system for their daily commute.

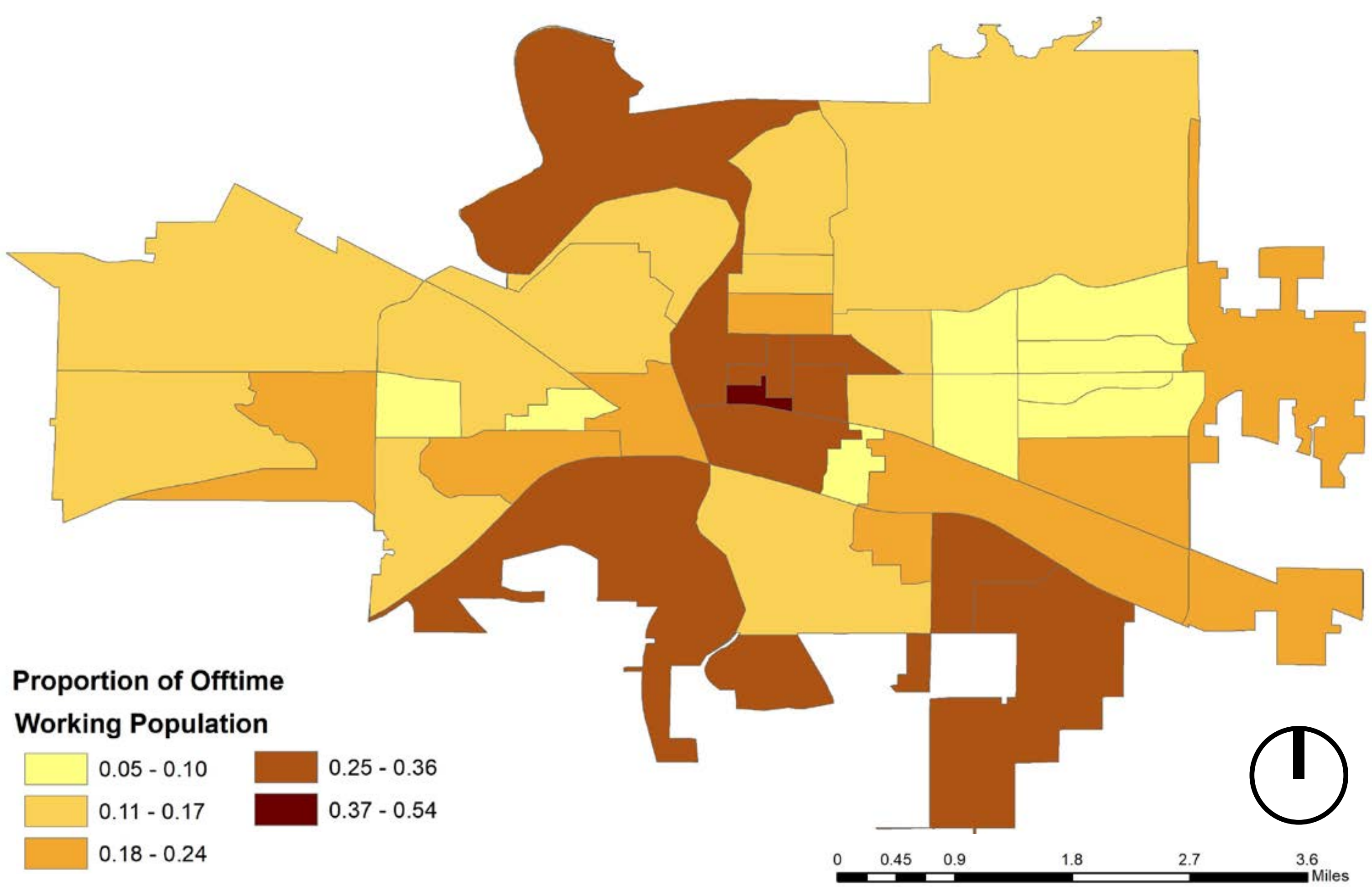


Figure A.2: Population and transit timing mismatch (Source: Authors)

Two transit systems currently operate in Iowa City - the Iowa City Transit system, and the CAMBUS transit system, operated by the University of Iowa Parking and Transportation Department. According to a survey conducted in 2013, Iowa City ranks 11th in the nation with respect to per capita transit usage; Iowa City transit users made an average of 66 trips in 2013. Despite the high usage of transit compared to other cities in the nation, Iowa City has been experiencing a constant decline in public transit ridership. During 2016-2017, Iowa City's transit system experienced a 7.9% decline in ridership compared to the previous year. 79% of resident's employment destinations are located within the city limits, whereas 21% of the residents work outside the city limits.

A significant portion of the population in different areas of Iowa City work second and third shifts and are not served by the current transit system schedule. Figure A.2 shows the distribution of population in different block groups whose work timing are not matched by the transit schedule. Therefore, options for improvement in the transportation services of Iowa City to match the travel needs of its residents should be explored.

Land use Category	Area, acres	Percentage
Business & Commerce	1435.06	3.43
Industrial	718.10	1.72
Institutional	4851.10	11.60
Mixed Use	8.90	0.02
Overlay	20279.15	48.51
Residential	14510.74	34.71

Table A.5: Land uses of Iowa City (Source: Authors)

A.11 IOWA CITY LAND USE

Most of Iowa City's land is zoned for residential purposes. Regarding residential zoning, several categories exist for classifying this land use. Table A.5 presents the amount of land each zoning classification has in Iowa City. An important observation is that different types of residential land uses comprise the largest amount of land use (in terms of acreage) in Iowa City while institutional land uses comprise the second largest land use in the city. However, a significant portion of the land is devoted to dif-

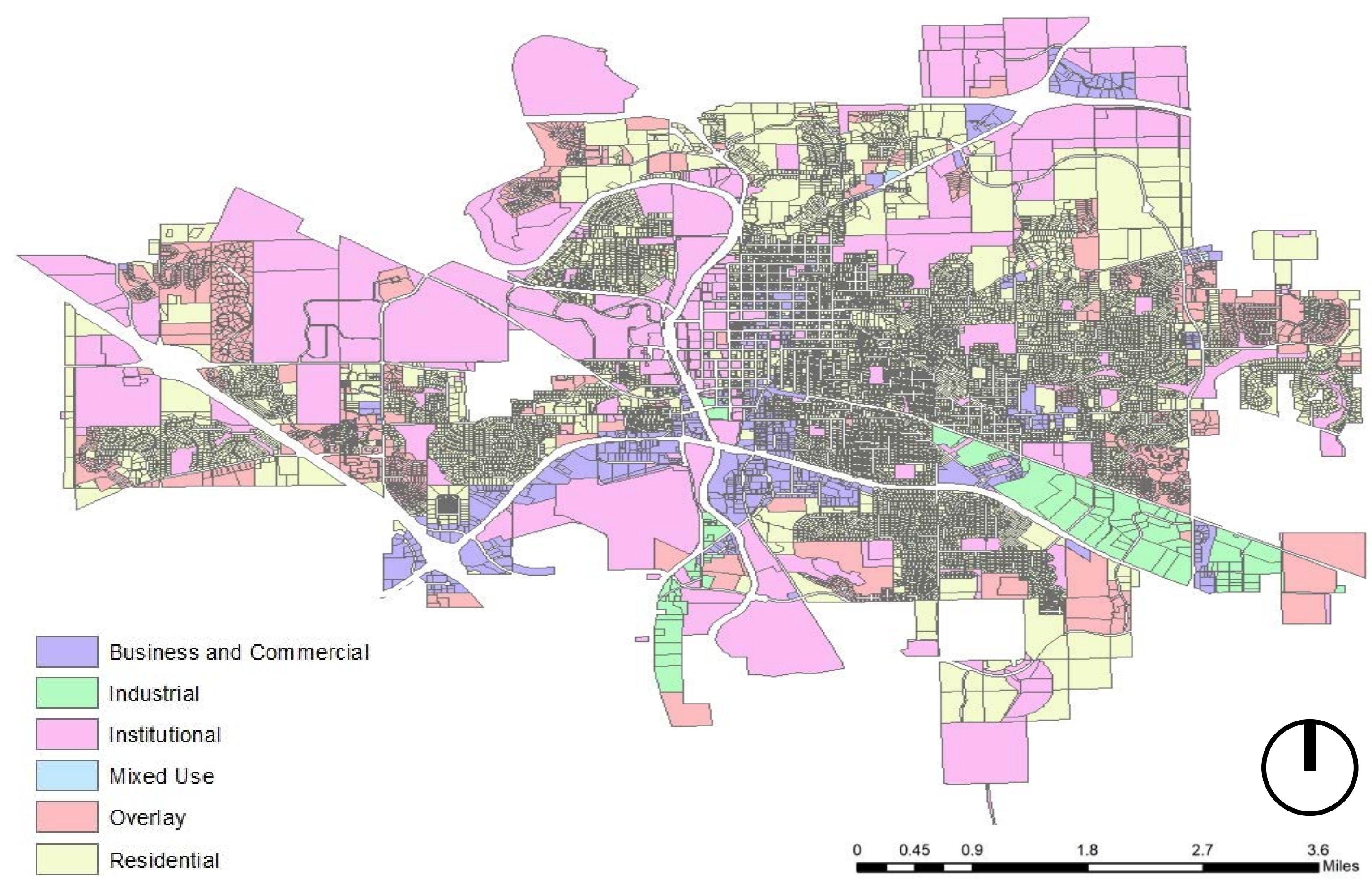


Figure A.3: Existing land use map of Iowa City (Source: Authors) ferent types of overlay zoning categories (48.51%). Figure A.3 shows the existing land use map of Iowa City. Iowa City has been annexing land in its periphery for new housing development which is anticipated to be a combination of both single and multi-family housing. This observation highlights the dynamic nature of land use in Iowa City and the incremental expansion beyond its current limits.

A.12 STAKEHOLDER QUESTIONNAIRE

OBJECTIVE

The University of Iowa's School of Urban and Regional Planning is working to understand the potential impacts of automated vehicle technology on the City of Iowa City. Our purpose for this meeting is to understand key stakeholders' opinions. It is our goal to incorporate stakeholders' feedback into a plan that may serve as a guide for the city in moving toward a predictable, equitable and safe future.

CURRENT HABITS AND CHALLENGES

Travel habits of commuter and leisure passengers (Private/Transit/Rideshare) and concerns about mobility and accessibility in Iowa City.

1. What are the main transportation challenges in Iowa City?

2. In your opinion, what is the most efficient mode of transportation for Iowa City?

3. Have you thought about the way the transportation network is structured and does it meet the needs for people at different times of day?

4. Broadly, if you were to envision Iowa City, what would the transportation services look like?

5. Are there areas in the city with an inadequate transportation service? (Low-Income Neighborhoods)

6. What would a well-served public transportation operation in Iowa City look like to you?

FAMILIARITY WITH AV

Familiarity with and general opinion about automated and self-driving vehicles.

7. What do you know about automated-vehicle technology?

8. What do you think about it?

9. What is your opinion of self-driving vehicles?

10. When do you think self-driving vehicles will be operating in cities? In Iowa City?

Familiarity with current automated-vehicle technology on their own vehicle(s).

11. Are you aware of the automated functions available in your vehicle?

12. Do you know anyone with a vehicle equipped with automated-vehicle technology? If yes, what is your opinion of it?

PROS AND CONS OF AV

Expected benefits of self-driving vehicles

13. How do you see self-driving vehicles impacting Iowa City?

14. Can you think of any benefits of automated vehicles for your professional field?

Concerns about using self-driving vehicles

15. What are your concerns about the safety of current generation of automobiles?

16. What are your concerns about the safety of automated vehicles?

Concerns about different possible implementations of self-driving vehicles

17. Do you expect negative impacts of automated vehicles for your professional field?

18. What ways could you foresee self-driving vehicles being deployed? (privately owned, shared (such as a shuttle), or both) ?

PROPENSITY TO USE AV

Overall interest in owning and willingness to pay for self-driving-vehicle technology

19. Are you interested in using automated vehicles to advance your work, operations?

21. If you have the means, would you prefer to own a self-driving vehicle in the future or would you prefer to subscribe to a service that allows access to a self-driving vehicle? Why?

22. Would you agree to pay a premium for an automated vehicle relative to the current price of a standard automobile?

23. If automated-vehicles are introduced, do you see an increase in access for all?

24. Do you agree that cities should invest in ADS infrastructure beforehand? Why?

Thank you so much for your valuable feedback and expert opinion! We may use the opinions you have provided as guidance moving forward with our adaptation plan. You are appreciated!

A.13 STAKEHOLDER LIST

Kelly Schneider, Mobility Coordinator for Johnson County

Tom Banta, Chamber of Commerce/Iowa City Area Development

Jeremy Endsley, Shelter House

Jim Sayer, UI Parking and Transportation Charter Committee

Marcia Bollinger, Iowa City Neighborhood Associations Liaison

Kent Ralston, City of Iowa City Neighborhood Services & Exec Dir Johnson Co MPO

Gustave Stewart, Student Government

Scott Cochran, Freight Community

Dan McGehee, NADS Director

Brad Neumann, Iowa City Assistant Transportation Planner

Jay Geison, Bicycle Advisory Committee

Dyllan Mullenix, Des Moines MPO

Brent Pritchard, Real Estate Professor/Agent

Brock Grenis, ECICOG East Central Iowa COGs, Transportation Admin/Planner

School of Urban & Regional Planning,
The University of Iowa,
347 Jessup Hall,
Iowa City, IA