Quantifying the Current and Future Transportation Landscapes in Charlottesville to Evaluate the Effects of Shared, Dockless E-Scooters on Mobility

(Technical Paper)

Evaluating Rules for the Successful Integration of New Modes of Mobility into Existing Transportation Landscapes

(STS Paper)

A Thesis Prospectus Submitted to the

Faculty of the School of Engineering and Applied Science

University of Virginia • Charlottesville, Virginia

In Partial Fulfillment of the Requirements of the Degree

Bachelor of Science, School of Engineering

Cameron Lloyd

Spring, 2020

On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

Signature _____ Date _____

Cameron Lloyd

Approved _____ Date _____

David E. Evans, Professor of Computer Science, Department of Computer Science

Approved _____ Date _____

Kathryn A. Neeley, Associate Professor of STS, Department of Engineering and Society

Introduction

In order to evaluate the prospective benefit of a new mode of transportation, personal electric scooters, we must understand both the current status of transportation options in Charlottesville as well as past examples of how new options rose to prominence or failed to take hold in the transportation landscape. Electric scooters fall under the umbrella of micromobility, along with other "forms of transport that can occupy space alongside bicycles." (Populus Technologies, Inc., 2018, p. 2). Dissecting the past transitions for both personal transit and public transit uncovers commonalities in cities' and residents' motivations to adopt and promote a new form of transportation. In addition to the social aspects of adopting a new mode of transit, it is crucial to understand what technological improvements have happened and need to happen for the integration of e-scooters into multi-modal transit routes for residents. Community members and leaders alike experience contention regarding the introduction, or invasion as some have complained, of e-scooters. (Whitford, 2018, n.p.) Although labeled as a nuisance to cities and dangerous to riders and others on the road, e-scooters have seen also seen enthusiastic adoption by riders who appreciate the convenience, cost, and fun of using them. The differing, but vocal opinions surrounding e-scooters call to question a more considerable uncertainty: how will future technological advancements in batteries and autonomous abilities change the transportation landscape, and how will cities and residents, and governments act proactively or reactively to these changes? More importantly, what are some rules and frameworks with which stakeholders can work to ensure an equitable, successful adoption of a promising future of personal transportation?

For the promise of a new, efficient, and environmentally friendlier option (over cars) of e-scooters, there have been some significant roadblocks, besides just potholes. Safety is a great

concern, not only for riders but also the residents of cities who have seen streets and sidewalks now inhabit e-scooters in inconvenient and dangerous ways. Because of these concerns, numerous cities have taken action. San Francisco, for example implemented a temporary ban on e-scooters and now heavily regulates them to ensure riders do not leave them in hazardous or inconvenient places. Cities that enact full bans on e-scooters miss the adverse complications, but at the cost of rejecting what could be a more efficient, convenient, and enjoyable mode of transportation for its residents. For my technical topic, I will seek to quantify the positive and negative impacts shared electric scooters have had and will have on Charlottesville's transportation landscape, specifically around the University of Virginia. Understanding both current and future implications through data will help stabilize the unknowns of a new mode of transportation rapidly entering the landscape and help to prepare the community for a smoother and more successful adoption. For my STS research, I will investigate, propose, and evaluate different frameworks and guidelines for the successful integration of new modes of mobility, namely micromobility, into existing sociotechnical systems. Guidelines will benefit stakeholders like city planners, universities, and residents, who can then use these findings to make informed decisions on how or whether to allow and promote private companies to place e-scooters in their communities.

Technical Topic: How can we quantitively measure success or failure of new transportation options in Charlottesville?

In order to understand the need for analyzing the efficiencies and drawbacks of shared, dockless e-scooters (Charlottesville's Lime scooters), it is helpful to look at where the introductions of the new transit have gone well, and where there is room to improve. Scooter

company Bird saw 10 million scooter rides within the first year of their shared dockless scooters appearing in Southern California. (Gonzalez, 2018, n.p.) That success is in part since most transit, and personal vehicle rides are very short (less than 5miles), especially on college campuses and military bases (Zarif, Pankratz, & Kelman, 2019, p. 4). Populus Technologies found that 45% of trips made in the U.S were less than 3 miles in length, and riders use personal vehicles for 78% of those trips. (Populus Technologies, Inc., 2018, p. 4). The current transportation options in many cities lend themselves to improvements in both time and carbon emissions efficiencies for riders, and the first mile/last mile problem is a viable place for innovation.

Transportation in urban areas has the potential to extend employment opportunities for individuals of varying socioeconomic statuses (Smith & Schwieterman, 2018). However, there are transit deserts, which (Jiao & Dillivan, 2013) define as areas "areas that lack adequate public transit service given areas containing populations that are deemed transit-dependent." Analyzing Charlottesville's transit landscape similarly to Jiao and Dillivan's Chicago study will help ensure that city government leaders are aware of transit deserts and meaningful plans to promote equity among all residents by giving clear and succinct places and plans to improve.

While there has been great success in adoption rates for e-scooter companies like Lime, Bird, and Jump, there are still significant issues with the maintenance, safety, environmental, and financial costs associated with the current business models (Whitford, 2018). Failing to address these consequences can lead to a variety of undesirable outcomes. If scooters are poised to bring equity to those without personal vehicles, there need to be measures to ensure scooter companies distribute their units equally. For example, in D.C. scooter allocation is dependent on dense areas, but limits on fleet size mean companies choose where to place their scooters carefully, and

typically avoid lowest-income neighborhoods (Lazo, 2018). There are also several environmental concerns. While scooters do not emit carbon at use-time, the manufacturing, maintenance, and distribution all carry high carbon costs. (Hawkins, 2019, n.p.) also includes recent efforts by Lime and Bird to use sturdier scooters, as increasing the lifetime of use would significantly improve the environmental impact of them.

My technical research will primarily build upon strategies undertaken by Smith, C., & Schwieterman, J. P. (2018) and Jiao & Dillivan (2013) in order to establish why e-scooters can have positive effects for increasing mobility. These papers scope one city and study in-depth the past, current, and future transit options throughout varying neighborhoods using gap analysis for transit demand and supply. Using open source technologies like OpenStreet Map, LODES, LEHD, and OpenTripPlanner, my research will entail evaluating whether the addition of a new mode of transit (e-scooters) would serve to increase mobility in Charlottesville, and constructing a report detailing the benefits and consequences of either keeping the pilot study of Lime Scooters or revoking them. The main challenges will entail accessing and reformatting the data needed so that different sources can be compatible with the tools mentioned above and summarized below. This figure shows the breadth of available technologies available to gain insights into transportation landscapes in Charlottesville.

OpenSource Tool	**Features**	**How to use**
OpenStreetMap	Tags for geographic locations of pedestrian paths, public transit stops, and bicycle routes.	Can use pre-made community sourced maps or use API's to fetch additional data.
LEHD: Longitudinal Employer-Household Dynamics	Provided by the census bureau, LEHD "makes available several data products that may be used to	OnTheMap application and in raw form as a set of comma separated variable (CSV).

	research and characterize workforce dynamics for specific groups."	
LEHD Origin-Destination Employment Statistics (LODES)	LODES provides "spatial distributions of workers' employment and residential locations and the relation between the two at the Census Block level."	OnTheMap application and in raw form as a set of comma separated variable (CSV).
OpenTripPlanner	OpenTripPlanner (OTP) is a "family of open source software projects that provide passenger information and transportation network analysis services."	"Directly via its web API or using a range of Javascript client libraries, including modern reactive modular components targeting mobile platforms."

Figure 1: Table summarizing some of the available technologies to be used for technical research project shows the numerous open sourced technologies available to use. Created by author.

STS Topic: How can we define rules and guidelines for integrating new modes of transit?

The sociotechnical system surrounding micromobility, specifically shared dockless e-scooters, is one that is currently emerging as a balance between residents, scooter companies, and city governments. Bird and Lime began operations in 43 markets without government permits or consent. (Portland Bureau of Transportation, 2018) The rapid introduction caught many cities off guard with how to adjust and integrate the scooters into their streets safely and effectively. For that reason, cities, including San Francisco, home to headquarters of many of the scooter companies, have placed outright bans to avoid the scooters' infrastructure problems entirely. Since that ban, the city has enacted what it deems sensible regulations like requiring the vehicles to be locked to something when not in use.

In my STS research, I will articulate clear and precise rules and strategies of resolving the conflict between the regulators, regulations, scooter companies, and residents of cities concerning paths to a successful integration (or ultimately) rejection of shared dockless e-scooters. While a significant component of the STS research will need to build upon the technical research to evaluate the current policies, understanding the problem frame in the actor-network theory model will promote the importance of the technologies involved as well as the organizational and cultural factors. Failing to address how a productive partnership between various stakeholders could take place would result in more disgruntled residents, cities, and private companies, while also rejecting what could be a more efficient and cost-effective mode of transit for many. Research must also address the concerns about equity, or else more cities will observe what Washington D.C. has, a widened transportation gap that follows the economic gap in various neighborhoods. Proactively evaluating the possible options will help to avoid the adverse outcomes of either a rule-less and dangerous transportation option or further transportation troubles from squandering the prospects of innovation. Proposing guidelines and suggestions in a way that fosters agreement and enthusiasm from both community leaders and residents will increase the chance of success for changes other than e-scooters to take root as well.

Establishing such strategies for integration will build upon Mesthene's research on understanding the impact, both positive and negative, that technological change has on humans and society. (Mesthene, 1970) Mesthene's work begins by expressing the inadequacies in viewing changes as wholly beneficial, or wholly detrimental to the present societal frameworks, instead of arguing that there is value in calling to question the goals of society when disruptive changes are occurring. Additionally, this research will use the STS concept of actor-network

theory (ANT). Analyzing sociotechnical systems benefits from the emphasis on symmetrical influence because it captures the complex interactions between humans, the technology they create, and the social environment in which they create the technologies. (Latour, 1992) The main challenges will likely stem from understanding and framing the interactions and attempting to anticipate what the effects of those would be in the long term. Mapping the origins of the problem domain is useful to evaluate the various actants in the problem network, as it unveils the broader context and situations which the new developments have sought to improve.

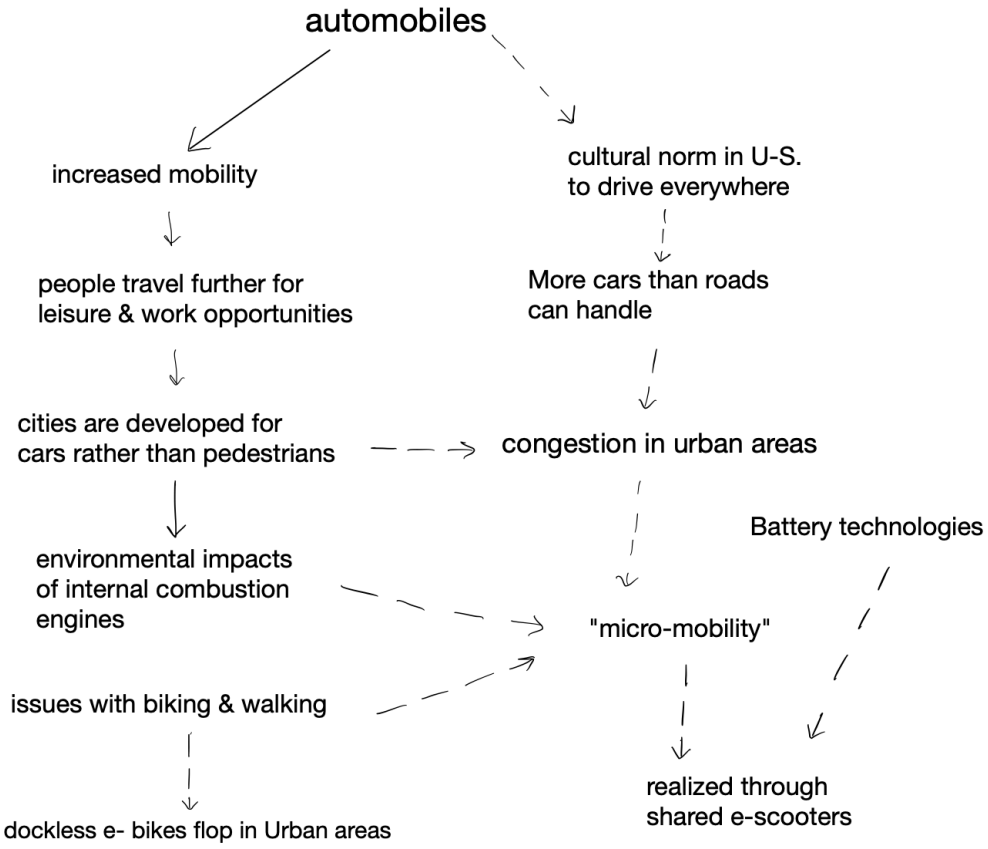

Figure 2: Flowchart on the origins of the sociotechnical problem, showing context for why e-scooters have emerged so rapidly and how they might not fit with existing car-oriented infrastructure. Created by author.

Additionally, this research will investigate the role of engineers as technological mediators, as Downey does in his work (Downey, 2005). Rather than having advancements and new mobility modes introduced without considerations of all stakeholders, the enumeration of rules and guidelines for all stakeholders will help to integrate e-scooters or other micromobility modes into existing transportation landscapes. Describing both the problems e-scooters could solve, and the problems they create concerning as many stakeholders as possible can help to arrive at a common solution, even if stakeholders view and describe the problems differently.

The deliverable of the STS research will be a greater understanding of the guidelines for successful introductions of new modes of transit: namely micro-mobility forms like shared dockless e-scooters. For the technical research, the deliverable will be a report of the quantified evaluation of the changes to Charlottesville's transportation landscape regarding the introduction of shared dockless e-scooters. The status quo of cities passively dealing with this new technology can result in a less safe, environmentally friendly, and equitable transportation landscape for residents. These deliverables will contribute to the future decisions of local and state governments regarding regulations, which can guide the environmental, economic, and social successes of e-scooters.

References

Armstrong, M. (2018, November 12). *Slate*. Retrieved from Can we make electric scooters work on college campuses?: https://slate.com/technology/2018/11/college-campuses-electric-scooters-bird-lime-razor.html

Clewlow, R. R., & Mishra, G. S. (2017). *Disruptive Transportation: The Adoption, Utilization, and Impacts of Ride-Hailing in the United States.* Davis: UC David Institue of Transportation Studies.

Gonzalez, G. (2018). 14 Months, 120 Cities, $2 Billion: There's Never Been a Company Like Bird. Is the World Ready? INC. Magazine.

Hawkins, A. J. (2019, August 2). Electric scooters aren't quite as climate-friendly as we thought: A life cycle analysis of the dockless scooter industry reveals plenty of carbon emissions. https://www.theverge.com/2019/8/2/20751610/scooters-electric-dockless-carbon-emissions-study-life-cycle-analysis

Hollingsworth, J., Copeland, B., & Johnson, J. X. (2019). Are e-scooters polluters? The environmental impacts of shared dockless electric scooters. *Environmental Research Letters Volume 14, Number 8*.

Jiao, J., & Dillivan, M. (2013). Transit Deserts: The Gap Between Demand and Supply. *Journal of Public Transportation Article Volume 16, Issue 3*, 23-39.

Lazo, L. (2018, December 15). In the move toward personal mobility devices, D.C.'s poorest are left behind - again. *The Washington Post*.

Mesthene, E. G. (1970). Technological Change: Its Impact on Man and Society. Cambridge: Harvard University Press.

Populus Technologies, Inc. (2018). *The Micro-Mobility Revolution: The Introduction and Adoption of Electric Scooters in the United States.* San Francisco: Populus AI.

Portland Bureau of Transportation. (2018). *2018 E-Scooter Findings Report.* Portland. https://www.portlandoregon.gov/transportation/article/709719

Smith, C., & Schwieterman, J. P. (2018). *E-Scooter Scenarios: Evaluating the Potential Mobility Benefits of shared Dockless Scooters in Chicago.* Chicago: Chaddick Institute for Metropolitan Development at Depaul University.

Whitford, E. (2018). *The Scooter Wars of 2018*. Retrieved from Inside Higher Ed: https://www.insidehighered.com/news/2018/10/10/e-scooters-are-causing-safety-and-accessibility-headaches-campuses

Zarif, R., Pankratz, D. M., & Kelman, B. (2019). *Small is beautiful: making micromobility work for citizens, cities and service providers.* The Deloitte Center for Integrated Research.