Prospectus

Human Powered Vehicles

(Technical Report)

Moving Charlottesville: How Charlottesville's Transportation Network Can Shape Its Future Success

(STS Research Paper)

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Introduction

The number of jobs within a typical commute distance for people living in high-poverty urban areas declined by nearly 15% between 2000 and 2012 (Stromberg, 2015). This is not a new trend in the United States, as for decades urban sprawl has routinely left behind inner-city poor residents, and their transportation infrastructure is largely to blame. For decades the urban transit systems of cities have been caught in a vicious cycle, as agencies meant to cater to poorer residents are underfunded, causing reduced service and therefore less reliability. Today, as modern smart-city initiatives are being considered in municipalities across the country, accessibility must be chief among the objectives of new technology.

In Charlottesville, Virginia, a small city of 50,000 that is home to the University of Virginia, local groups and government officials are already beginning to evaluate the implementation of smart-city technologies. As Charlottesville continues to expand both its population and transportation infrastructure, it will have to take into account the stakeholders it plans to serve, and what values it will prioritize. My groups focus is on providing the greater Charlottesville community with guidelines for future smart city projects. These objectives will take into account stakeholders and partners, their values, and what elements of a smart city can best address their needs.

In this paper, I will be exploring some of the smart transportation systems other US cities like Charlottesville have taken to address accessibility, and assess their feasibility. Turning to a case study, CHO acts as an example of how to explore the relevant social groups, definitions of access and disability needs, and strategies already in existence and proposes that might overcome the challenges.

Technical Project Report

Transportation infrastructure is not a problem unique to the United States. Globally, billions of people deal with poor, inefficient, and unsafe transportation on a daily basis. While modern technological innovations aim to push the limits of efficiency and accessibility, established modes of transit still have the power to shape communities if implemented correctly. One such example of these established transit modes is Human Powered Vehicles (HPVs). Annually, the American Society of Mechanical Engineers sponsors a competition in which teams design and build performance oriented HPVs. These vehicles must adhere to strict competition rules, and must also be backed by the research and documentation we will have conducted throughout the design process.

Our team of 13 mechanical engineering undergraduates decided to research several design options before brainstorming a preliminary vehicle. The form of our final submission was to be shaped not only by the rules set forth by ASME, but by the specific obstacles our vehicle and riders will face in competition. Chief among these obstacles is the main performance component of the competition, an endurance event. In a Le-Mans style race, all teams will complete a predefined course as many times as possible in a set number of hours.

The team conducted research both into the specific requirements of the competition and the designs of past teams that have found success. Our largest constraints, budget (initially $2000) and time to manufacture, allowed us to eliminate designs that were either very expensive, or difficult to create as amateur machinists and welders. To alleviate some of the budget constraints, our team applied for grants through the UVA Parents Fund and CIO Rolling-Round Funding. Upon being awarded another $2000 towards our project, our team could better conceptualize our design.

We decided on a recumbent tricycle frame design, with a “tadpole” wheel arrangement (2 front wheels for steering, 1 rear for power) (Appendix: Figure 1). Additionally, with the grant money we determined that a partial fairing could be purchased in order to improve aerodynamics throughout the long endurance event. Per the ASME rules, all front wheels must be equipped with brakes. We thought having 2 wheels in the front would also aid us in having a short stopping distance due to their increased contact with the road. Recumbent tricycles are also notable in that their combination of optimized driver position and low center of gravity makes them very quick. Our design further capitalizes on this by having a rear drive wheel with a gearset. Changing gears will help the vehicle achieve its top speed, while also being efficient in hills and in the drag race.

After this preliminary design was presented to our faculty advisor, several notable changes were made. The most significant improvements to the vehicle’s design were in its frame material and construction. Initially made of 1” diameter AISI 4130 steel tubing with a wall thickness of .095”, the frame was just strong enough to meet the loading requirements of ASME while weighing under 30 pounds, a team determined maximum weight. By changing to 1.5”diameter tubing of the same steel with a wall thickness of .065”, we were able to add strength while keeping our weight nearly constant.

The design of the hoop that protects the driver, called the Rollover Protection System (RPS) by ASME, was also an area of major improvement. In the initial design as seen in Figure 1, the shape was made by welding straight sections of tubing together. Following a recommendation from Sebring Smith, a faculty advisor for the Virginia Motorsports club, we changed the RPS design to a single, bent tube. This change can be seen in our FEA analysis tests (Fig. 2 and Fig. 3), and increased both the strength of the design and its ease of construction.

With our frame design confirmed for the time being, our team now turns its focus to the integration of the drivetrain and frame. One major obstacle to this is the ability of our vehicle to accommodate drivers of varying height. To do so, we plan on implementing an adjustable crankset at the front of the vehicle. This will not only allow the pedals to reach all sizes of driver, but also satisfies another competition requirement; the innovation of a new system from scratch.

With this on the horizon, as well as the fairing design and physical tests of the drivers, our team is looking forward to a busy spring semester. When all is said and done, we should have an efficient, reliable, and high-performance human powered vehicle.

STS Thesis

I. Introduction

The average American commute by bus is 45 minutes each way, compared with 24 minutes for commuters who drive alone (Stromberg, 2015). Many would attribute this to the changes in cities following WWII; widespread car-centric development. But despite the expansion of the highway system in the 1950s and 60s, public transit here is worse than in countries with similarly aged cities. Transit blogger Alon Levy notes: "In 1912, Boston had this great public transit system, with four subway lines and streetcars that fed it, and then they spent the next 60 or 70 years destroying it." A major problem that occurred in this time was municipalities treating transit as welfare (Stromberg, 2015). While this seemed to address the key value of accessibility, it quickly was undermined by a lack of reliability. When politicians see the transit industry as a form of welfare, it prevents local agencies from charging high enough fares to provide efficient service, effectively limiting transit to those who are too poor to drive (Stromberg, 2015). Because of this, according to Levy, it's considered acceptable that busses come once an hour because they are the only option for people who can't afford anything else. In future implementations of smart transportation, both accessibility and reliability must be considered in order for stakeholders to benefit.

To explore this, and how revised transportation could positively impact citizens of Charlottesville, we must explore how similar communities are tackling this issue of transportation. During this process, prior research, along with the knowledge gained from engaging with the Charlottesville community members will be analyzed to help to understand the interactions of stakeholders, their values, and the solutions that they seek. This framework, which utilizes a SCOT approach, will also help determine the missing pieces of the puzzle that must be evaluated further in the future.

When talking about any modern smart city, new forms of mixed modal transportation immediately come to mind. These, such as electric scooters or bike share programs seem to address both values of smart transportation services; accessibility and reliability. Through this exploration, I hope to find answers to the following questions: What transportation options are cities implementing that Charlottesville could adopt for itself? And, if these methods are taken, how will citizens be impacted both positively and negatively?

II. Literature Review

When mentioning future city transportation, it is impossible to ignore the impact of mixed model programs. Currently, scooter and bike sharing programs are taking many american cities by storm, and serve as an inexpensive and accessible alternative to traditional transportation options. However, though revolutionary, these programs may end up serving a population that ultimately doesn't need them. While the average US bike-commuter is disproportionately low-income and non-white, bike and scooter share users are whiter, wealthier, and more likely to have a college degree (Stromberg, 2015). So if mixed modal sharing is to be more accessible, why not just move docking areas to low income neighborhoods? Adonia Lugo, a researcher who's studied biking habits among low-income communities, says it's because, for low-income commuters, bicycling is a last resort prompted by their inability to afford a car.

For many, ride-sharing services like Uber could be an answer to poor public transit. Uber can especially help alleviate the risks of relying on fixed-schedule transit. "Predictability is crucial for poor people," says Robert Hotchkiss, a low-income San Diego transit user, "I would often walk rather than wait on a bus that might or might not come," (Stromberg, 2015). Uber has the ability to provide those unable to afford a car an option that is both reliable and accessible, but likely still unaffordable. Uber, and similar services like Lyft, then would serve as a complement to public transit rather than a substitute, with average Uber fares being $5 against the $1 average transit fare (Hall, Palsson, Price, 2018).

While novel, these approaches don't yet satisfy the requirements for smart transportation infrastructure with regard to accessibility. It's possible the United States will need sweeping changes to adequately address the needs of the public with regard to public transit, but should those changes occur the benefits will be significant.

Research has shown that ease of access to transport has a stronger influence on whether someone will earn more than their parents did than the level of crime in their area or whether they grew up in two-parent households (Criden, 2008). This is especially important in Charlottesville, a city with a racial and economic divide due in part to the University's history. As mentioned before, the number of jobs within a close commute distance of inner-city residents is declining. Charlottesville too continues to expand both outward and upward, and reliable public transportation can help reduce economic inequalities by providing access to higher paying jobs outside of a citizen's primary residential area (Criden 2008). Additionally, residents with reliable public transportation options will stimulate the local economy by spending household income on resources other than transportation.

While Charlottesville, and the majority of cities in the United States, has a long way to go before they can address the needs of their citizens with regard to accessibility and reliability, the charming university town seems poised to be a leader among small smart cities of the future. While not without its past errors, the work of the University of Virginia through executive projects and student efforts alike is ready and excited to help make Charlottesville "smarter" with regard to more than just transportation. As both a resident of Charlottesville and student at UVA, I look forward to observing the city's pursuit of reliable, accessible transportation, and the ways it will shape a community that deserves only the best.

III. Framework

The SCOT framework, or Social Construction of Technology, is a popular framework when analyzing topics that affect varied groups of people. It pairs the stakeholders with their challenges, as well as solutions that may address the problems they face. With a problem as complex and multi-faceted as public transportation, SCOT acts as a way to simplify the vast network of stories, needs, limitations, and potentials that exist for a city, and for a community. With regard to Charlottesville, and especially my project of assessing solutions for its citizens, this framework was well suited. Chief among the stakeholders were the citizens, but it quickly became apparent that this was too broad an umbrella to use. Below is a sample SCOT diagram for Charlottesville transportation. While not comprehensive, it illustrates well the approach that was taken for evaluation.

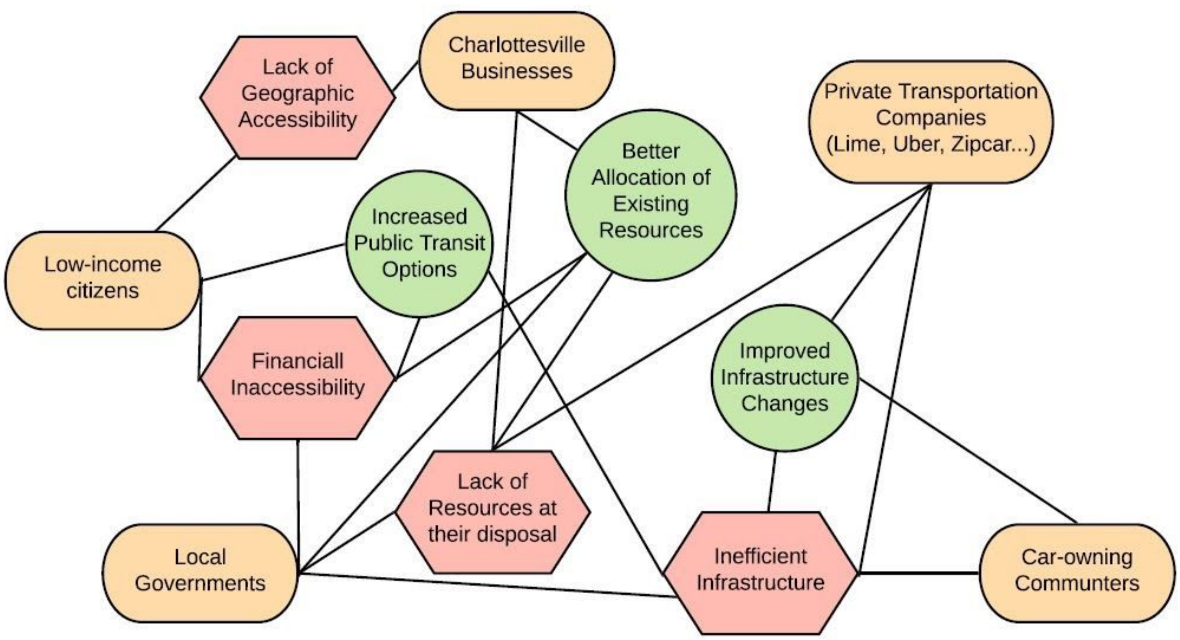

Diagram 1: Charlottesville SCOT

In orange are some of the stakeholders of Charlottesville. They include low-income citizens, car-owning commuters, local governments and others. Each bubble is connected to several others, with problems facing that stakeholder in red and possible solutions in green.

One of the tremendous benefits of a framework such as this is that it lays bare the shortcomings in current understanding. While elaborated on in the following sections, it was clear that the methodology of analysis, or how these groups, problems, and solutions are defined and redefined, needed further refinement. While it was known that both financial and geographic accessibility were challenges facing many citizens in Charlottesville, this framework made it clear that we lacked an understanding of the extent of these problems, and the desires of those who face these challenges. As such, this, or any framework can be thought of as an equation. Each input must be considered, and only when all of the pieces are in place can the whole image be seen. In Charlottesvilles case, more voices need to be heard before a solution can be deemed ideal for each stakeholder involved.

IV. Methodology

As mentioned, while the framework serves an equation representing a given place and its groups, a chosen methodology is a way of finding these inputs. This paper analyzes public transportation through a lense of accessibility, noting past failures and successes as well as current practices. This research can also be applied to Charlottesville through community outreach focusing on current infrastructure and its accessibility. This engagement, which can help create a bigger picture beyond the scope of local policymakers or citizens, will then help to characterize the actual state of transportation in Charlottesville, and the extent to which future smart technologies can be implemented to benefit all stakeholders.

Previously, I had interviewed an anonymous Charlottesville resident regarding their perceptions of transportation accessibility, as well as smart city technologies. While this direct community engagement certainly helped characterise the situation, it was clear that other entities must be consulted as well. Consulting with municipal government leaders, city planning officials, engineers, and developers will allow for a better understanding of the community, as well as the processes that must take place in order to create meaningful change while working within the constraints of government. Moving forward, better understanding the interactions of these groups, as well as how the citizens of Charlottesville perceive them and their efforts will be paramount to the continued study.

V. Discussion and Next Steps

This fall has been a busy time, but it has contributed greatly to my understanding of the Charlottesville community, and the issues facing its future implementations of smart transportation technology. In the spring, to further my understanding of the accessibility issues in Charlottesville, as well as the groups they affect, I plan to attend meetings of the City Planning Committee to hear specific points of feedback from citizens. While interviewing a Charlottesville community member proved valuable, as was alluded to earlier, hearing from different groups within Charlottesville will ultimately help to better understand the solutions the city needs to pursue.

Charlottesville is an incredible place, and a city rife with potential smart city technologies. The University, its students, and the community as a whole are excited to see what the future holds. Charlottesville has the chance to look at its past, and the past of cities like it, and set a course for a smart future. If the voices of different stakeholders are heard, I have no doubt that the city will be exceptional in its implementation of smart transportation initiatives, and make transit more accessible for all.

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Appendix

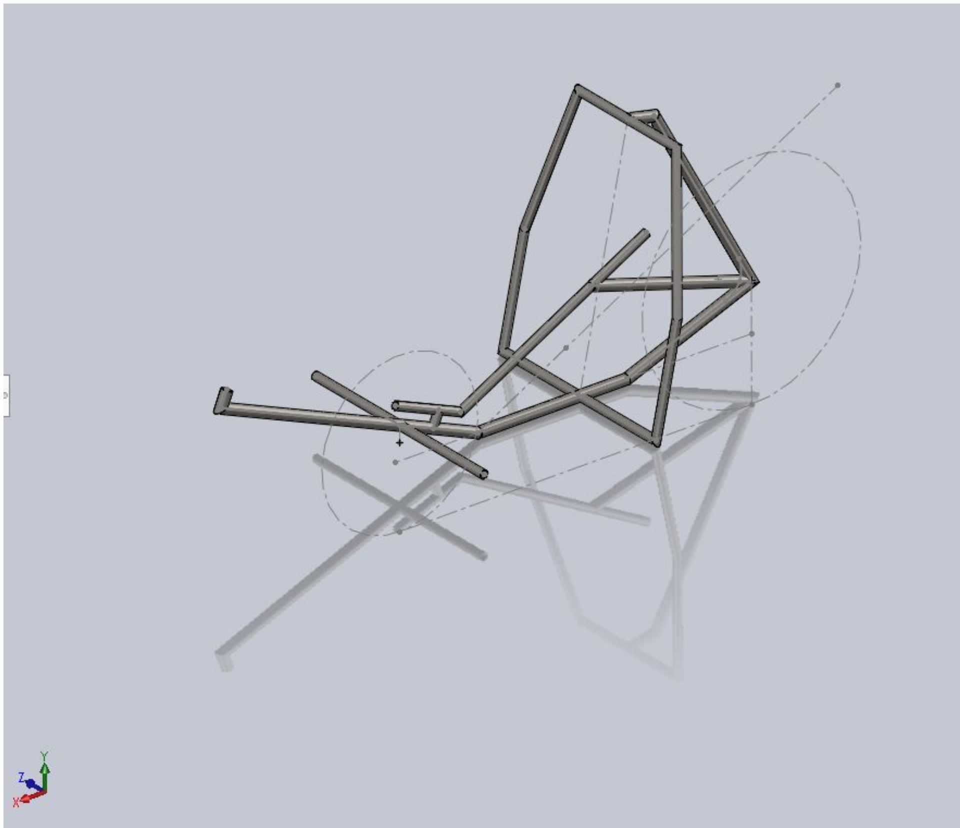

Fig 1. Preliminary Frame Design

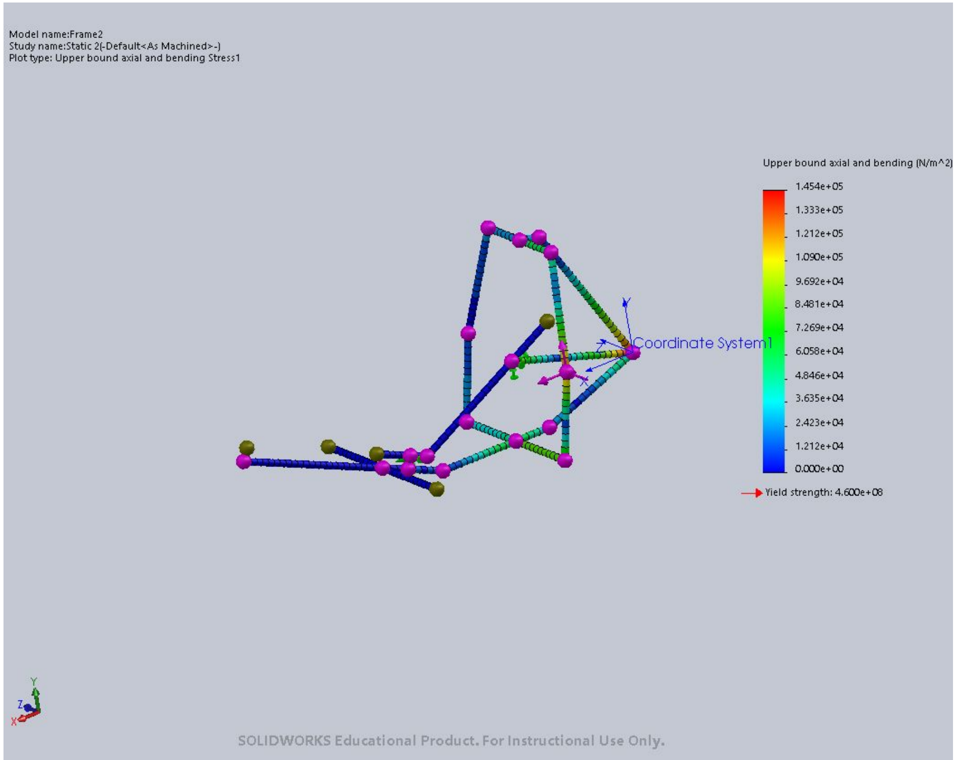

Fig 2. Preliminary Frame FEA

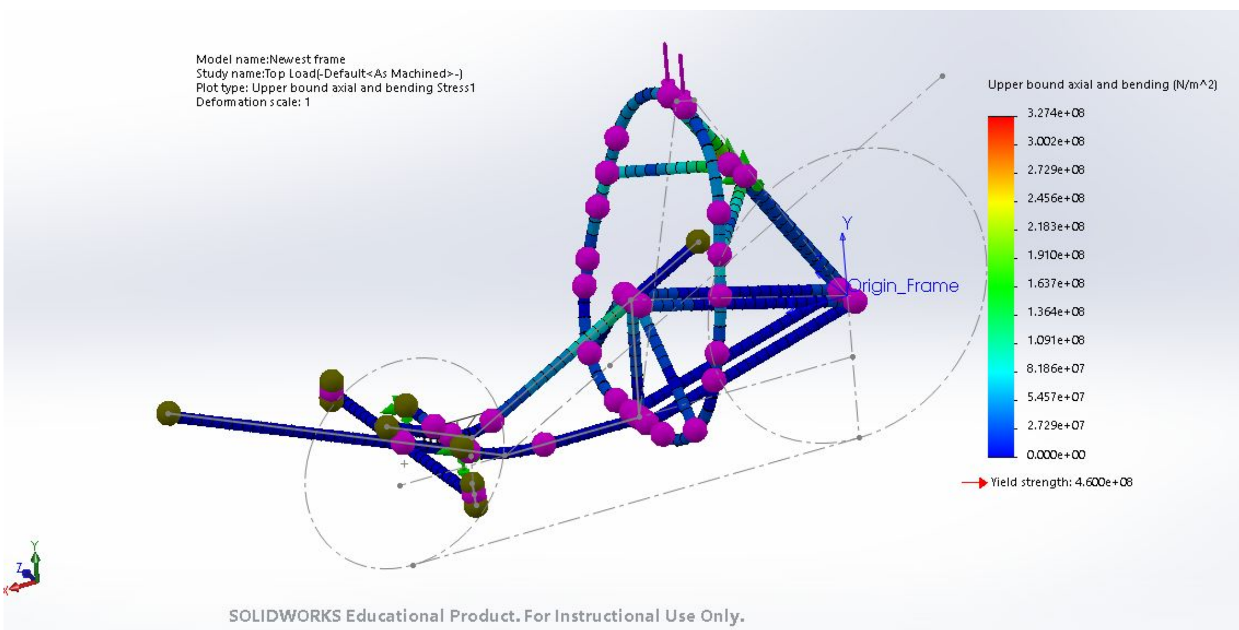

Fig 3. Redesigned Frame FEA