Prospectus

Ethical and Sustainable Alternative to Human Powered Transportation

(Technical Topic)

Actor-Network Theory and Socio-Technical Factors of Implementing a New Form of Transportation in Local Roadways

(STS Topic)

By

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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.

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Introduction – Sociotechnical Problem

Carbon emissions are a huge problem the Earth is facing today, and is a large factor contributing to global warming. The rising temperatures on Earth and the increasing amount of greenhouse emissions are problems that need to be solved soon, before irreversible effects may occur (Kakouei et al., 2012).

The University of Virginia has recently announced a new goal to become carbon neutral by the year 2030 ("Climate Action & Energy," 2020). To reach this goal, the University and the general Charlottesville community have cut down on carbon emissions at the source. A large contributor of carbon emissions is from petrol powered automobiles such as cars, busses, motorcycles, golf carts, street scooters, etc. These forms of transportation are all integrated in the University of Virginia's business and general system, whether it be from university supplied services or use by their student and staff bodies ("University of Virginia 2017 Greenhouse Gas Inventory Report," 2017). To help their fight against global climate change and further carbon emissions, the university must find a way to reduce their usage of gas-powered vehicles. To address the issue of emissions from automobiles, I will propose an idea for a more sustainable and functional form of transportation in the form of a human powered vehicle (HPV).

It is clear that by slowly adapting the UVa and Charlottesville community to more modern and sustainable forms of transportation, social, economic, and political factors will arise. Questions of how the community will fair, or if it will adapt to a culture of more human powered transportation over the convenience and prevalence of busses and cars may also materialize. A case will be studied about a new implementation of cycling infrastructure in a city to see how a network of factors affected this city's cycling culture. These factors have to be further analyzed and understood to be able to implement HPVs in a city's transportation subsystem successfully.

This analysis can be used to further see how a new vehicle will fair in a city like Charlottesville, and how the community will view and affect a similar project.

Both technical and social aspects must be researched and analyzed to effectively and efficiently design and execute a new and safe alternate to gas powered automobiles. In this prospectus, I will propose a new form of human powered vehicle that is sustainable, and is effective and versatile enough to be used in an everyday scenario and robust enough to be used in a multitude of terrain and situation. With the usage of Actor-Network Theory, I will also analyze how implementation of new biking infrastructure in a Canadian city helped shift the city into a greater biking culture, and what factors contributed to their project's success.

Technical Problem

Human powered vehicles are transportation systems that carry humans and or cargo, and run solely on power generated by the human. HPVs are a great alternative to gas powered vehicles, because of their impact on the environment. Gas powered automobiles are responsible for 26% of all greenhouse gas emissions globally (Chapman, 2007). These greenhouse gasses, with carbon emissions being some of the most potent, are responsible for the exponentially rising temperatures our planet earth has seen over the few centuries ("Overview of Greenhouse Gases," 2020). Human powered vehicles, on the other hand, only contribute to greenhouse gas emissions during the production and manufacturing process of their lifecycle, and contribute none when being used by a consumer (Neves & Brand, 2019). Besides their clear environmental benefit, HPVs provide fast and efficient transportation at a much lower cost and a much more compact size when compared to gas powered vehicles.

HPVs have been around for centuries and include vehicles such as bicycles, push scooters, railway carts, inline skates, skate and longboards, etc. Out of these examples, the bicycle has had the most success, with its efficiency, light weight, compact size, and overall prevalence on the road. In many major cities in the United States, bicycle usage by population reaches up to over 20% (Beuhler & Pucher, 2011). Because of their prevalence, infrastructure and policy has had to adapt to include space and designated lanes for bikers. Although bicycles have proved very efficient and popular, safety is always a concern when riding a bicycle on a busy road. With almost no safety features, bicycle accidents happen all too often, and often result in serious injury to both the artifact, but more importantly the user (De Guerre et al., 2018). Another pitfall of the bicycle is their lack of cargo space. Although a great human transporter, any other cargo the user may want to carry, will have to be carried on person with limited size and space. A new, more reliable human powered vehicle must be made to compete with the large market that is gas powered automobiles and still offer the less expensive and more compact alternative, but prioritize the safety of the user most of all.

Our goal, as the University of Virginia's Human Powered Vehicle team, is to create a new alternative to the human powered vehicle that prioritizes versatility, robustness, and the safety of the user. After design and production, our vehicle will be adaptable enough to work in a multitude of landscapes and environments, and reliable enough to use as an everyday commuter, whether it be attending a UVa class, or going to the supermarket to carry groceries. To do this, I am proposing a semi-recumbent tricycle style vehicle with a tadpole layout (two wheels in the front and one in the back). This vehicle will be made with a steel frame and roll cage to provide the user protection from all angles. The HPV will also come with a fairing and will place the user

in an ergonomically designed reclined position to maximize the aerodynamics of the vehicle, and ensure the most efficient power output to input ratio by the user.

To complete this project, new and previous mechanical engineering methodology my team has learned and practiced will be used to make the most safe and ethical product possible. Norton's 10 Step design process will be implemented into the planning and manufacturing portions of our project, as it provides the clearest and most ethically feasible way to create a new technology from scratch. 3D modeling software will also be used to design the frame and fairing itself and to analyze the strength and safety factors of the vehicle under a variety of realistic and field possible forces and stresses. Finally, towards the beginning of next semester, assembly techniques such as welding and molding will be used to fashion the vehicle itself. These methods will all be integrated together to create a new style of HPV that prioritizes further safety and convenience for the everyday user.

STS Problem

In 2015, the City of Victoria, British Columbia, Canada announced an ambitious goal and plan to increase the prevalence of transportation by bicycle in their city. Their goal was to reach 25% of trips by bicycle with a demographic that mirrors their population. The government of Victoria committed $9 million (Canadian) to the project with a goal of more than three quarters of Victoria's land base to be within 400 meters of an all ages and abilities (AAA) bicycle facility. Their plan was to increase streets sizes to accommodate for bicyclists as well as adding more bicycling facilities in general. These facilities included fully protected on-street facilities, as well as shared road facilities. Because of this project, Victoria saw a large increase in commuters that used bicycles over cars or other forms of motorized transportation. Data was collected from Victoria as well as two other cities of similar size, demographic, population, and area that didn't

have as extensive of a bicycling network: Halifax and Kelowna. From this data it was found that Victoria had a population of 8% that used bicycles as their primary form of transportation, while Halifax and Kelowna had a population of 3% each (Winters et al., 2018).

It is clear to see that the city of Victoria did increase and foster a larger bicycling culture in their city through the completion of this project. It is thought that the increase in bicyclists seen in Victoria can be solely attributed to the increase in bicycling infrastructure and facilities in the city. Although the increase in availability of these facilities has increased the prevalence of biking in Victoria, it is not the sole reason that this project in its entirety was a success. Other factors also contributed to the overall success of the project and also helped foster a larger biking culture in Victoria. I believe that factors such as perceived safety and perceived convenience of the overall biking system greatly affected how the population reacted to the project, and allowed the population to feel comfortable using this infrastructure on a regular basis (Hull & O'Holleran, 2014). Without the perception of safety or convenience, the general population would feel deterred from using the available amenities. If infrastructure and physical facilities are looked at as the sole reason for success in a project like this, it is failed to see how these other factors have influenced the project and helped Victoria in becoming a more physically active and sustainable city. Without looking at these other factors, when implementing a similar project in other cities like Charlottesville, the project may fail and cost the government and its citizens a lot of social and economic hardship.

I argue that physical infrastructure and facilities, as well as the implementation of perceived safety and convenience all allowed the City of Victoria to increase their bicycling culture and population. Further support and analysis of my claim can be drawn upon from the science, technology, and society (STS) framework of Actor-Network Theory. Actor-Network

Theory is a socio-technical framework in which heterogeneous actors are interconnected and work together to create a network or system for a common purpose (Cressman, 2009). Actor-Network theory is helpful as it allows me to analyze how physical and conceptual, as well as human and non-human actors play a role in the network that is the bicycling culture in Victoria as a whole. The urban planners and politicians of Victoria act as a network builder, and create the technology that will ultimately be utilized by the general population. This population's perceptions of the bicycling infrastructure in the city decide if the technology will be used, and therefore foster a larger cycling culture. The urban planners and politicians, the population, and the populations perceptions of safety and convenience are all actors that support the cycling culture in the entirety of Victoria.

To support my argument, further research needs to be done on how the user's perception of safety and convenience of the biking system in their town affects how or if they would use this infrastructure provided to them. I will analyze evidence from surveying a population like the one in Charlottesville to see how bikers use the limited but given biking infrastructure, and how they feel about the safety features provided and the convenience of it as a whole. I will also analyze journal pieces such as "Bicycle infrastructure: can good design encourage cycling" which provide insight about how perception of the infrastructure design encourages users to use these amenities more (Hull & O'Holleran, 2014).

Conclusion

In this prospectus, it is proposed that the technological and social impacts of implementing a new, more sustainable form of transportation will be analyzed to see how they affect the University of Virginia's and greater Charlottesville area's community and carbon emission count. The technical project proposes a new form of human powered vehicle that is

versatile and adaptable enough to be used in a plethora of scenario and situations. This semi-recumbent tricycle style HPV will be designed around the usage of an everyday commuter that provides a safe and utilitarian transport for a user, for example, like a student at UVa who needs a reliable and sustainable way to get to class or the grocery store. The STS work will provide a better understanding on what factors will contribute to the success of implementing a new transportation into a city's system by looking at an example of Victoria, Canada, and how they successfully fostered a larger biking culture in their city.

The success of this project will help contribute to the University's plan to become a carbon neutral system by 2030. This will ultimately help resolve the issue and heal the damages that carbon emissions and global warming has done to our fragile planet. On a smaller scale, a project like this can raise awareness and create a more health and environmentally conscious attitude in our University of Virginia and Charlottesville community as a whole.

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