

# **Human-Powered Vehicle**

(Technical Paper)

## **How the Wheelchair Contributes to Equality in Society**

(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

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Fall, 2019

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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

## **Introduction**

Biking to work increases 60 percent over the last decade due to environmental sustainability and affordability (“Biking to work increases 60 percent over last decade,” n.d.), but how much safety a bicycle has for its rider? 7997 Bicyclists in the United States passed away from 2007 to 2017 (IIHS, n.d.), which is two percent of motor vehicle deaths. Even though the bicyclists' fatality is relatively low, it shows the safety design of the vehicle needs improvement. Human Powered Vehicle project from the Mechanical and Aerospace Engineering Department opens opportunities for students to design a vehicle. The project aims to perform in ASME's international Human Powered Vehicle Challenge (HPVC) from April 26 - 28, 2020 and to develop affordable and reliable transportation for society. The vehicle also has higher safety compared to a bike since the design includes a crucial concern of the safety standard provided by the American Society of Mechanical Engineers (ASME). The propose of the project is also to design the vehicle not limited to the ambulatory, so the study of how the wheelchair affects society becomes an interesting, interdisciplinary STS topic for the future design. Humans firstly created the wheelchair thousands of years ago, (“Wheelchairs,” n.d.), and 1.7 million people use wheelchairs or scooters for their commutes (“Mobility device statistics,” 2018). Due to a large number of wheelchair users and the long historical development of the wheelchair, the wheelchair case study potentially represents how it has affected society and how the equality of people with disabilities changes according to the technology.

Therefore, to observe and analyze the social impact of the wheelchair, STS research includes legal regulations, wheelchair users' emotional perception, and the economic organizations related to wheelchair makers and users' employment in the study. The findings of

how the wheelchair contributes to equality in society will support significantly to the design development of the human powered vehicle in the future.

### **Technical Topic (Capstone):**

ASME's international Human Powered Vehicle Challenge (HPVC) opens a valuable opportunity for students to apply the engineering design principles into real world. The team aims to incorporate and apply materials, knowledge, and experiences, which mechanical engineering undergraduate students have studied for 3 years, to build a practical, reliable vehicle this year. The goal of this project is not limited only to construct a vehicle for the competition in April 2020 but also to develop the design with high-safety, reliable, alternative transportation. The team considers safety, speed, and comfortability as main design criteria to accomplish the goals. The vehicle has two front wheels and a rear wheel to enhance its stability and maneuverability (Greene, 2011). To improve performances of safety, acceleration, and turning, the team designs to minimize the height of the center of gravity of a vehicle included a rider (Diandra, 2014). To enhance safety when the vehicle accidentally rolls, the team designs a roll cage specified as the Rollover Protection System (RPS) by ASME. The team also chose 4130 annealed steel tube as a frame structural material to enforce the strength and reliability of the vehicle (Davis & Andrews, 2014). A rider will have a recumbent position due to its high output power with less aerodynamics drag compared to upright position (Minetti, 2014). When the output power increases, the speed increases due to less power loss. Then, the under-seat steering system locates on the side of the vehicle to associate comfortable control along with the rider's position (Horwitz, 2010). Also, the team will install the pre-made partial fairing at front of the vehicle to reduce drag force, which significantly increases the speed of the vehicle. Since riders in the team have a range between 5 ft 4 in to 6 ft, the vehicle can adjust the leg length to fit with

everyone by installing an adjustable leg length portion on the frame with chain tensioners to adjust the chain length accordingly.

In this semester, the team plans to finalize dimensions of all parts of the vehicle and prepare them for the construction and real testing phases next semester. The team uses computer-aided design (CAD) to computationally draw all parts (frame, drivetrain system, and steering) and assemble them together. To test the limit of strength of the vehicle in different scenarios, the frame team will apply the finite element analysis to the model in order to ensure the frame material and structure have strong supports for riders. The ergonomics team also works on measuring the maximum output power and finding the optimal recumbent position by testing at the Biomechanics lab. To pursue premade fairing with the minimal drag force, the fairing team will print 3D fairing of different shapes and test how much drag and flow shape look like in a wind tunnel experiment. After finishing the design phase, the team will work on combining all parts together by welding tube and putting parts in place as in the CAD model. The team plans to finish the construction phase within a month from the start of the spring semester. Then, the team will conduct a test drive, improve the performance, and document a report for the competition in April 2020.

**STS Topic:**

In 2017, Over 20 million people in the United States have serious difficulty walking or climbing stairs (Yang-Tan Institute on Employment and Disability at the Cornell University ILR School, n.d.), so they have more challenges to achieve some of their goals. For example, transportation between floors without using stairs takes a longer time and effort for those who use wheelchairs. The equality for people who use wheelchairs leads to important research questions: how the wheelchair impacts better accessibility from legal regulations and social

impacts, how the economic situation of people who use wheelchairs changes, and how the wheelchair affects emotional perception of wheelchair users in society. The stakeholders in this study include policymakers, wheelchair users, and economic related organizations such as employers and wheelchair industry to research how the wheelchair impacts society in terms of legal, emotional, and economic views.

The policymakers contribute significantly to the accessibility for wheelchair users especially in public transportation after establishing the Americans With Disabilities Act (ADA) in 1990 (Bezyak, Sabella, & Gattis, 2017). For example, the federal standard ensures that wheelchair users also have as much accessibility to public transportation as other people by including minimum requirements for transit vehicles such as doors, ramps, wheelchair securement systems, and communication systems (Steinfeld & Steinfeld, 2017). The ADA not only affects the policymakers to ensure that wheelchair users have equal accessibility but also affects awareness of other technologies such as public transportation to accommodate the wheelchair's properties.

The emotional perception of wheelchair users represents how and why the users satisfy or hope for better improvement of the wheelchair from their difficult experiences in their daily lives. 46 percent of people with disabilities, compared to 23 percent of people without disabilities, reported feeling isolated from their communities ("National Organization on Disability," 2000). Grant, a wheelchair user from the Guardian, states "I think we like to think [as a country] we're making progress. But in reality, we still get turned away from buses. We still have nowhere to live." Disabled people still encounter negative reactions in public in their daily lives (Ryan, 2017). The perspectives of wheelchair users show that the wheelchair requires

significant considerations, not only legal regulations but also social norms and non-disabled understanding to the importance of this issue.

The economic organizations including wheelchair makers and wheelchair users' employment reflect if the development of the wheelchair effectively encourages the acceptance and equality of the wheelchair users in society. When examining the economics of wheelchair production and usage, wheelchair innovation and job opportunities to wheelchair users are necessary economic parts to discuss. Everest & Jennings International, a dominant wheelchair maker in the United States in 1981, did not develop the wheelchair significantly regardless of the complaints of users' discomforts because of limited competition in the wheelchair industry (Kleinfield & Times, 1981). The inadequacy of wheelchair innovation raises the question of whether the wheelchair makers have developed wheelchairs for people or profits. However, when discussing employment opportunities of wheelchair users, the research is positive. Shore's research about the long-term effects of new wheelchair users in developing countries shows the employment rate increases in the short term and stays constant in the long term (Shore, 2017). The studies of the stakeholders in the economic part will show how the wheelchair impacts the outlooks of organizations towards the technology and equality for wheelchair users in society.

Technological fix is a STS framework explaining how people construct technology to solve social or complicated issues and create other issues from the solution (Newsberry, 2019). Due to side effects from each stakeholder, technological fix theory explains how the wheelchair has inherent impacts rather than its primary purpose, providing alternative transportation. Before the Americans With Disabilities Act (ADA) was released, Alan L. Breed, an orthopedic surgeon, claimed important concerns about the motorized wheelchair in 1982 (Breed & Ibler, 1982). The guideline for users and wheelchair status on streets, which affect pedestrians, needs to be

considered. ADA included those considerations which changed how disabled and non-disabled people behaved and interacted in society. Bodil Ravneberg, a social science professor of Høgskulen på Vestlandet, also supports how technology impacts people and creates technological norms without people's recognition (Ravneberg, Söderström, & Söderström, 2017). Even though Ravneberg does not specify particularly to how the wheelchair creates social norms, Roulstone, a professor of Disability Studies at the University of Leeds, explains how the social standard considers a wheelchair as a practical tool and why the attention of the wheelchair development today should be focused more on the societal functional development rather than the innovative development (Roulstone, 2016). Therefore, the research applies the technological fix theory to examine what and how the wheelchair has affected society, other related technologies from stakeholders' viewpoints, and previous scholar research in this theory and in wheelchairs.

### **Research Questions and Methods:**

- How the wheelchair impacts better accessibility from legal regulations and social impacts
- How the economic situation of people who use wheelchairs changes
- How the wheelchair affects emotional perception of wheelchair users in society

Methods for this research include documentary research, discourse analysis, and historical case studies. The documentary research such as “The Wheelchair: Enabled or Disabled? Houston, We’ve Had a Problem” by Roulstone and “The Long-term Impact of Wheelchair Delivery on the Lives of People with Disabilities in Three Countries of the World” by Shores contributes significantly to explain how the wheelchair impacts perspectives of people in society and leads to accessibility for wheelchair users and how the employment and emotion of people with disabilities change after using the wheelchair.

Discourse analysis will gather data about the experience and emotional perception of the wheelchair users to explore how wheelchairs impact their emotions and what they feel they achieved or struggled from this technology or society. The method includes an article interviewing wheelchair users by Ryan, “What is life really like for disabled people? The disability diaries reveal all,” and 500 sample Tweets related to the wheelchair. The study from articles and Twitter aims to observe insightful qualitative data from the article and perspectives in general fields how society thinks and affects the wheelchair-related issue.

The historical case studies approach will focus on two primary cases: “Wheelchair Maker Vs. Critics” from Kleinfield and Times and the history of Americans with Disabilities Act from Disability Rights Education and Defense Fund. Both cases show how equality for people who have disabilities become an important issue in society, what the wheelchair has changed society views about people who have disabilities, and how the wheelchair improves equality of wheelchair users in society.

### **Conclusion:**

The Human Powered Vehicle project's purpose is to participate in ASME's international Human Powered Vehicle Challenge (HPVC) and simultaneously learn during the design and construction phases along the academic year in order to pursue insightful perspectives of better design performance and contribution to societal development. STS topic aims to study how the wheelchair impacts equality in society by inspecting at views of legal regulations, users' emotional perception, and economic organizations. Then, the analysis will evaluate how the development of the wheelchair accomplished its main goal and its effects to equality in society. Both technical and STS studies will provide suggestion of improvement criteria and unintentional effects of how to develop of alternative transportations in the future. The technical



project team will finish building the vehicle and go to the competition in the next semester with well-documented reports and performance. Accordingly, the wheelchair study will illustrate significant findings of how the wheelchair affects equality for wheelchair users.

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