Thesis Project Portfolio

Development of an Autonomous Platooning Campus Vehicle System

(Technical Report)

The Environmental Impact of Lithium-Ion Batteries

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Autonomous vehicles have been the subject of many headlines for years now. They come with extraordinary promise contrasted with an uncertainty surrounding myriad facets of the technology. Autonomous vehicles have often been criticized for their safety and reliability for both their drivers and others on the road. I chose to examine a less scrutinized element of these vehicles to understand their power source, lithium-ion batteries. Alongside the booming electric vehicle industry, the production of lithium-ion batteries has exponentially increased. Through both a technical capstone project and an investigative research paper I will seek to understand the environmental impact of lithium-ion batteries.

Under the advisory of Professor Tomonari Furukawa, the campus vehicles team aims to develop an autonomous golf cart platooning system. Our sponsor, Club Car, graciously provided the research team with two golf carts. The end goal is to produce a cohesive system in which one cart will be manually driven while the other follows behind autonomously. The idea is to provide a new form of transportation around the grounds at the University of Virginia. Theoretically, once the system is perfected with two carts, there is no limit to the number of additional carts that could be added to the platoon. The University of Virginia's extensive campus littered with hills leaves much to be desired for any disabled or injured persons trying to make their way around. This system would drastically increase access with need for only one driver.

The fall semester was spent performing a thorough design process. Our team sourced customer needs from students and faculty at UVa. These needs were then translated into technical objectives that would serve as a reference as we entered the development stage. Our team divided the work into sections including steering, braking, acceleration, wiring, and coding. Over the course of the following months we began designing our system through computer aided design and quantitative analysis all while following the plan laid out in our Gantt chart. The

spring semester consisted of fulfilling many purchase orders and actually enacting our designs from the fall. Many roadblocks came and went as we finished out the design on both carts. Primarily, the wiring from past years on the carts was extremely messy and we had to start almost from scratch. The final and most difficult step was developing the algorithm for platooning. Using a combination of AR tag tracking with a mounted camera and a feedback loop between the carts the system was completed.

This technical capstone project inspired me to look into whether or not lithium-ion batteries are truly as good for the environment as they are advertised to be. Although the vehicles themselves are not emitting dangerous greenhouse gasses, there are many adverse effects that arise from the production, use, and disposal of these batteries. The paper focuses mainly on their use in autonomous vehicles due to its relevance to its paired technical project, but lithium-ion batteries are used in a plethora of other applications such as electric toothbrushes and personal electronics like cell phones and tablets. There are many issues in regard to production including land degradation, water and atmospheric pollution, and inhumane mining conditions. The processes to mine the necessary elements to create one of these batteries requires enormous amounts of water salinization and large vehicles that destroy the surrounding environment. Moreover, we do not know the result of the pollution from the heavy machinery in production as well as the byproducts from the charging and discharging of these batteries composed of toxic chemicals. On that note, the disposal of lithium-ion batteries raises grave concerns as they have very limited recyclable materials.

The research paper will apply Actor-Network Theory (ANT) to perform the analysis on the relevant social groups and human and non-human actors in the environmental impact of lithium-ion batteries. Some of the groups include the manufacturers and users. I illustrate

how these groups not only influence the development of the technology, but how the technology has, can, and will influence these groups in return. In addition, the paper provides safer and more recyclable alternatives to lithium-ion batteries. It also discusses ways in which policymakers and battery manufacturers can take action to decrease their impact on the environment. Ultimately, the paper provides a clear overview of the environmental impacts from mining, production, usage, and disposal. Going into detail about the effects allows for a connection between the pertinent social groups and an opportunity for the reader to think about potential solutions to the present issues.