FSAE Car Clutch Automation System
(Technical Paper)

Shortcomings of Artisanal Mining:
A SCOT analysis of corporate-led mining projects in the DRC

(STS Paper)

A **Thesis Prospectus Submitted to the**

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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

In 2035, Battery Electric Vehicles (BEVs) are expected to make up the majority of new vehicle sales for the first time. This timeline assumes no change in policy, which could bring the transition even faster. The world is moving towards a more environmentally conscious future and with it begins the phasing out of Internal Combustion Engines (ICEs). The number of ICE vehicles on the road is expected to plateau in coming years and will begin to decrease after 2025, becoming the minority by 2040 (BloombergNEF, 2021). Fabricating a BEV in place of an ICE is not a trivial change to make, however. The batteries and motors required in a BEV demand a much more diverse list of materials than that of an ICE. One such critical mineral is cobalt, a metal used in the battery. 70% of cobalt is produced in the Democratic Republic of the Congo (DRC), a problematic supply chain that this project will focus on (IEA, 2021).

Both projects in this prospectus arise from my deep interest in automobiles. I have been a member of the Virginia Motorsports team since my first year at the University of Virginia and have always sought to learn more about how cars work. The STS project explores the relationship between the growing global BEV industry and the mining industry in the DRC. The technical project does not deal with mass produced vehicles, but rather a custom race car. SAE International hosts several competitions which challenge university students to expand their education outside of the classroom. The Virginia Motorsports team is entering a car in the Formula SAE competition, where university teams compete against one another in several challenges. The focus of the technical project will be on a single subsystem of this car and attempt to improve performance at competition. Although the work on the technical project may not have the same direct implications to the automotive industry as are found in the STS project, both projects will help me in seeking a potential future career in the industry. As BEVs become

the main focus of automakers, a deeper knowledge of the mineral supply chains expanded on by the STS project and the hands-on automotive engineering experience gained through the technical project should prove useful.

Technical Project

The Formula SAE competition does not consist of a single race, but rather several events. The team must provide multiple drivers, as drivers are limited to competing in a single event. This project hopes to close the gap between the off-the-line acceleration of the least and most skilled driver operating the car. The car's engine came from a motorcycle and thus has a cable operated clutch which is currently operated with a lever behind the steering wheel. The clutch engages and disengages the engine from the transmission and the wheels. This can pose a problem to less experienced drivers who may have never used a hand-operated clutch or driven any manual transmission vehicle at all. Delays in finding the bite point, where the clutch begins to engage engine power to the wheels, and the risk of stalling the engine when the car is being operated by an inexperienced driver prompted this project to replace the manual cable operation of the clutch with an electronically controlled clutch. This project will ideally speed up all inexperienced drivers and not hinder those with more experience.

Many factors are important in considering the viability of any design. The speed and accuracy of the system are of course extremely important for it to function. A good design should perform as well at off-the-line acceleration with an inexperienced driver as a skilled driver performs using the manual clutch. Weight and cost are also concerns as the total weight of the car affects top speed and acceleration and the team works with a finite budget. A good system will be lightweight and cost effective. Safety is extremely important as students will be

operating the vehicle, so ideally a design will be able to fail safely and have some form of manual override. These and other design criteria were set out by my technical team to evaluate model concepts.

STS Project

Electric Vehicles (EVs) are touted as saviors in the climate crisis, and they will undoubtedly reduce emissions and help the climate. While BEVs' environmental advantages are difficult to measure directly against ICEs', BEVs classically have a lower overall environmental impact, producing on average 33% less greenhouse gasses over their lifetime. This impact varies heavily depending on the makeup of the electric grid used to charge the BEV in question, but as electric grids become cleaner, the advantages of BEVs will grow (Lattanzio, 2020). BEVs are not, however, completely free of sustainability issues. This project intends to focus on issues relating to the cobalt supply chain within the DRC. Roughly 20% of the cobalt coming from the DRC comes from artisanal miners. These are workers with no formal wage who dig cobalt out of the ground and sell it. In 2018, there were an estimated 225,000 of these artisanal miners in the DRC, 35,000 of whom were children, some as young as six years old (Kara, 2018). In high concentrations, cobalt can cause lung disease and heart problems, and artisanal miners exposed to dangerous amounts of cobalt face detrimental health effects. Cobalt mines can also destroy landscapes and pollute surrounding environments, further harming community health (Watts, 2019).

In 2019, a myriad of technology companies including Apple, Google, and Tesla were sued in US courts on behalf of a group of families in the DRC who had children injured or killed in mining accidents while partaking in artisanal mining. The suit claims these companies

knowingly purchased cobalt being sourced from child labor for use in the batteries in their devices and in doing so were complicit with the mining companies in producing unsafe working conditions and allowing child labor to enter the supply chain. The suit also claims that these companies have the means to ensure that child labor and unsafe conditions are not present in their supply chains but choose not to act (Kelly, 2019).

In the DRC there have been a number of formalization projects which intend to bring artisanal miners into the legal supply chain of cobalt and ensure accountability and ethical sourcing. These programs consist of sectoring off specific areas in which artisanal mining may occur and forcing artisanal miners to have identification and documentation in order to work in these areas. These programs have improved to a degree the safety of miners and allowed for a means of auditing of the supply chain, but they are not without fault. Exploitation of workers and allowance of child labor is still possible even in these formal mining areas. Additionally, miners are still not provided a wage and are vulnerable to price fluctuations. Responsibility for mining conditions is pushed from tech companies onto the mining and refining companies. Risks of price volatility are pushed from mining companies onto the miners, who are not provided a wage or other protections or assurances (Calvao et al., 2021).

Methodologies

The Social Construction of Technology (SCOT) framework will provide a lens through which to examine BEVs and cobalt mining practices. SCOT is a social constructivist framework, meaning that it fundamentally believes technologies to be formed by the social structures around them and not vice versa. Within SCOT, the relevant social groups and their relationship with and views of a technology are examined to determine how the technology developed (Pinch, 1984).

This project will examine how the many relevant stakeholders, including consumers, automakers, mining companies, the Congolese government, and the Congolese people, view cobalt mining and BEVs and the positive and negative effects that these technologies have on them. Through analysis of these stakeholders, I will explore where responsibility for ethical sourcing of cobalt lies and how that responsibility is being avoided. As BEV production increases what changes need to be made and by whom in order to achieve an ethical cobalt supply chain?

Conclusion

Through a process of ideation, screening, and scoring my technical team has landed on a design for an automated clutch consisting of a hydraulic system driven by an electric linear actuator with an inline manual override lever. A microcontroller will track the position of the linear actuator using a built-in potentiometer and take input commands from the driver using custom made paddle buttons on the back of the steering wheel. After implementing this system there is room for continued work by integrating wheel speed sensors into the control system. This would allow for a complete launch control system in which the microcontroller adjusts the clutch to prevent the tires from slipping and ensure maximum acceleration off of the start line.

To continue work on the STS project will require a more detailed list of stakeholders in the cobalt supply chain and an in-depth analysis of their relationships with the BEV and cobalt mining industries. Through this analysis I hope to determine which stakeholders are not meeting their responsibilities and discover what actions from all stakeholders could improve the supply chain.

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