Thesis Project Portfolio

Systems Analysis and Negotiation of Strategic Partnerships in the Supply of Biofuels to Commercial Aviation

(Technical Report)

Addressing the Ethical Implications of Cobalt Mining in Electric Vertical Takeoff and Landing Vehicles (eVTOLs)

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

As the aviation industry faces increasing pressure to decarbonize, sustainability has become a driving force behind innovation in both aircraft design and fuel sourcing. My technical and STS research projects are connected by this shared commitment to sustainability in aviation, though they approach the issue from opposite ends of the value chain. My technical work focused on modeling and optimizing supply chains for sustainable aviation fuel (SAF) to Dulles International Airport (IAD), while my STS research explored the ethical implications of eVTOL development, particularly the exploitation embedded in the cobalt supply chain. Together, these projects examine how the pursuit of "clean" aviation is often complicated by underlying logistical and ethical tradeoffs that are too often ignored.

My technical project used systems analysis to study SAF distribution to Dulles International Airport. We applied the Freight and Fuel Transportation Optimization Tool (FTOT) to model possible feedstock and processing facility locations across the state and proposed routes that minimize cost and environmental impact. We also analyzed the interests of different stakeholders, including fuel producers, airlines, airports, and local governments, and proposed negotiation strategies for aligning goals and overcoming infrastructure and investment barriers. The goal of this work was to provide actionable strategies for enabling a scalable SAF supply chain that supports state and national climate goals for aviation.

In contrast, my STS research examined the darker side of clean aviation by investigating the hidden ethical costs of lithium-ion batteries in eVTOLs. Using Actor-Network Theory, I mapped out the global cobalt supply chain and showed how the success of eVTOLs depends on a deeply exploitative system of labor in the Democratic Republic of the Congo. While these aircraft are marketed as sustainable and zero-emission, their batteries rely on cobalt sourced from

regions plagued by child labor, unsafe working conditions, and environmental destruction. Through this framework, I argued that no aviation technology, no matter how innovative, can be considered truly sustainable if it ignores the injustices embedded in its supply chain.

Working on these two projects in tandem gave me a broader and more critical perspective on what sustainability in aviation really means. My technical work emphasized how SAF infrastructure can enable greener flight, but my STS research reminded me that sustainability cannot be reduced to emissions alone. It must also include ethical sourcing, social equity, and global accountability. This interplay helped me better understand the complexity of systems engineering in the real world, where technical feasibility must always be evaluated alongside social responsibility. Ultimately, these projects deepened my awareness of how even well-intentioned efforts toward decarbonization must be scrutinized for their broader consequences because the future of sustainable aviation depends not just on innovation, but also on integrity.