**Thesis Project Portfolio**

# American Institute of Aeronautics and Astronautics: Hybrid-Electric Regional Turboprop Design Competition

## Conceptual Design of the Songbird-E

(Technical Report)

# Analyzing the Socio-Technical Sustainability of Lithium Mining on Local Communities in the Lithium Triangle

(STS Research Paper)

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Bachelor of Science, School of Engineering

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## Contents of Portfolio

Executive Summary

American Institute of Aeronautics and Astronautics: Hybrid-Electric Regional Turboprop Design Competition

Conceptual Design of the Singbird-E

(Technical Report)

Analyzing the Socio-Technical Sustainability of Lithium Mining on Local Communities in the Lithium Triangle

(STS Research Paper)

Prospectus

## Executive Summary

The global aviation sector contributes 2.1% of the total carbon that humans emit every year, about 915 million metric tons in 2019. Air travel also emits contrails and nitrous oxides into the atmosphere, which, along with carbon, serve to warm the planet. With the growing need to combat global emissions, the US aviation sector set a goal to achieve net-zero emissions by the year 2050. To achieve this goal, engineers are turning towards green aerospace technologies, such as hybrid electric power, which is power derived from both burning fossil fuels and electricity. Hybrid electric power has many benefits, most importantly the drop in emissions from using electricity instead of fossil fuels. However, hybrid power does have issues: it can be hard to source materials, and it can be especially complicated and heavy to employ in aircraft. As the technology stands currently, it is unclear if hybrid electric aircraft are viable. However, engineers are working to improve the technology. Hybrid electric is the future of environmentally friendly aviation. The technical and STS portions of this project both analyze different aspects of this research space. The technical project aims to design a hybrid electric turboprop capable of reducing emissions compared to conventional turboprops. The STS project analyzes the sociotechnical sustainability of lithium mining in South America.

For the technical project, my eight group members and I were tasked with designing a hybrid electric turboprop. Our design had to meet requirements laid out by the AIAA in their request for proposal. The most stringent requirement was that our design must reduce the block fuel burned by 20%, when compared to a conventional, fossil fuel burning aircraft, with an entry into service of 2035. Since aircraft design is such a multidisciplinary field, each member was put in charge of an aspect of the design. My design area was stability and control, ensuring that our final design was stable and controllable in flight. To begin, we researched state of the art aircraft

technologies to inform our initial design. Then, we created an initial rough design, then iterated on that initial design. To perform each iteration, we used a software called FLOPS, which would analyze the mission, to determine fuel and total weights. Each iteration changed an aspect of the design, to optimize our design. However, we were constrained by design requirements in our proposal. Our final design was a four-engine turboprop, with two conventional engines, and two turboelectric motors, which are essentially on-board generators, which generate electricity which power electric motors. Our results showed that a hybrid electric turboprop is feasible, however, it may be difficult to market. Since electric technology is relatively new, it is currently more expensive than conventional, even with the added fuel savings. Another major conclusion we found was that the current state of batteries is not advanced enough to implement for aircraft, as they are far too heavy.

The STS research project aimed to determine the sociotechnical sustainability of lithium mining on local communities in the Lithium Triangle Region of South America. As mentioned above, batteries are a possible eco-friendly electric technology that can be employed in aircraft. The most common battery type is lithium-ion batteries, which can be used in anything from aircraft to cars to laptops. Lithium for batteries must be mined, and large deposits of lithium exist in the so-called Lithium Triangle, a region including parts of Argentina, Bolivia, and Chile. To mine lithium in this region, transnational companies negotiate with provincial governments and local populations to secure mining rights. However, there is a history of exploitation, where the needs and wants of the locals are ignored by the companies and the governments. I argue that this is unsustainable for these communities. It is technically unsustainable because of water rights. Lithium mining uses large amounts of water, in an otherwise arid region of the desert. Locals rely on water for their livelihoods, but research has shown that the total amount of water

is decreasing in the region. The current method of lithium extraction is also socially unsustainable due to uneven negotiations. For example, in Olaroz in Argentina, mining company officials presented locals with little to no information about a mining project in the area but went ahead anyway. Through the lens of sacrifice zones, shortages in water and uneven negotiations will inevitably lead to conflict and protests. I argue that this will be socially unsustainable for local communities, whose wishes are being ignored. To combat this, the current methods will have to change to better address the needs of the locals.

To conclude, both projects this year were successful. We successfully showed that hybrid electric aircraft are a feasible way to combat global emissions. I personally learned a lot about the design process overall. In the future, engineers should try to incorporate battery technologies into aircraft, as they will most likely be the future of eco-friendly aviation. I also successfully showed that the current methods of lithium mining are unsustainable for local communities. Mining negotiations are unfavorable to locals, and mining in general is depleting invaluable water. I believe the provincial governments should do more to protect the needs of locals surrounding mining projects. Future researchers should analyze policies that address this, to determine what policies are successful in the long term at maintaining stable communities.