Thesis Project Portfolio

AIAA 2022-2023 Undergraduate Hybrid-Electric Regional Turboprop Aircraft

(Technical Report)

Analysis of Aluminum Recycling through the Social Construction of Technology

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

As global concerns for climate change rise, many different efforts are being put forward to counteract the human effect of our environment. This portfolio includes two aspects in reducing humanity's environmental impact. The technical project will explore the design of a high efficiency hybrid electric regional turboprop while the science, technology, and society (STS) project analyses the social construction of modern aluminum recycling. While quite different in subject, the two topics are both important steps to a more sustainable future. The technical project's final deliverable is a design report detailing the full conceptual design of a hybrid electric aircraft capable of transporting fifty passengers 1000 nautical miles (1150 miles) with an entry into service year of 2035. The STS project's final deliverable is a paper applying the Social Construction of Technologies (SCOT) framework to aluminum recycling and investigating how social influences shape what we know of recycling.

Our goal of the technical project was to submit to a design competition with the American Institute of Aeronautics and Astronautics (AIAA) based upon their request for proposals (RFP). One major challenge facing the aviation industry today is the contributions to global emissions. One method to reduce the total amount of emissions is through hybridization of the propulsion system. This means that electrical systems replace or supplement some area of the traditional propulsion system. The specifics to the implementation of the electric system were analyzed and compared against each other. The general design and outer mold line (OML) was created in Open Vehicle Sketch Pan (OpenVSP). Aerodynamic values of the aircraft were obtained through programs like VSPAero, FlightStream, and XFLR5. SolidWorks was used to evaluate structural integrity of the aircraft. A combination of XROTOR and GasTurb, along with some self-made MATLAB scripts, were used for propulsion specifications. All of this is put into a program called Flight Optimization System (FLOPS) to analyze performance across a full flight. Finally, the model was input into the Advanced Aircraft Analysis (AAA) program to estimate the costs of the aircraft. Multiple designs incorporating a variety of possible aerodynamic, weight and propulsion modifications were compared against each other to develop the final design. My main focus was on the propulsion side, where I wrote MATLAB scripts to take data about turbine engines, output from GasTurb, to provide propulsion thrusts for various hybrid propulsion systems. We were able to show that our final design could have a 30% reduction in fuel when compared to current aircraft of similar class. It utilizes two gas turbines and two electric motors to power 4 sets of propellers. It also applies technologies like high temperature turbine blades and superconducting motors. Aircraft like the ones we designed could be steps in electrifying the entire aviation industry to eventually reduce effective emissions to 0.

My STS project focuses on the recycling of aluminum. As it is a technology, it can be analyzed using SCOT. In SCOT, all technologies are not developed through straightforward, objective "science based" approaches but rather through the influences of many social groups and their desires from the technology. Through looking at the design of technologies this way, more useful insight can be gained for future improvements of the technology. Aluminum recycling was chosen as a topic for my background in aluminum research, along with the environmental benefits associated with aluminum. Furthermore, aluminum is a particularly interesting metal since the process for extracting aluminum from mining is relatively complex. Because of this, humanity did not start using aluminum parts until the late 1800s despite the fact that it is the most common metal element found in the earth. On the other hand, aluminum recycling is relatively more energy efficient than the recycling of other materials, making it a good choice for initial analysis. I first researched many different aspects of both aluminum recycling and mining in order to compare the two. This included environmental, health, and economic contributions to the two different processes of obtaining aluminum metal. Then, I identified many social groups for which aluminum recycling may affect. I then used my research to identify the main desires that each social group has for the recycling process. I identified two main groups of desires: environmental and economic. In the case of alumium recycling, the economic and environmental incentives often align in a way that SCOT refers to as “design flexibility”. This concept of design flexibility is crucial moving forward as other materials have differing levels of design flexibility which govern the driving forces needed for recycling. SCOT analysis could be impactful to identify crucial areas needed to improve environmental benefits of other recycling processes.