Thesis Project Portfolio

American Institute of Aeronautics and Astronautics: Aerial Firefighting Aircraft Design Competition

(Technical Report)

The Conflict of Increased Reliance on Aviation and Environmental Initiatives

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Novel applications are one aspect of increased reliance on aviation that offers a glimpse at the future of flight, but the unabated growth of the industry also reiterates the need for a comprehensive assessment that accounts for social and environmental impacts in addition to economic significance. Beyond the novel use of airplanes for fighting wildfires, they are increasingly used in conventional applications to transport passengers and billions of dollars worth of cargo annually. This portfolio includes two projects. In the technical project, a large aerial firefighting aircraft is designed and evaluated to help combat the increasingly prevalent and dangerous wildfire threat across the globe. Throughout the design process, the conflicting requirements of performance, cost, and environmental impact will necessarily be addressed. The STS research project investigates the issue of environmental impacts and sustainability in the aviation industry from a more holistic perspective by providing a thorough assessment of the role of various stakeholders as the industry comes to terms with emphasis on limiting environmental impacts and the need for sustainability. While aviation is relied on at ever growing rates across the globe and for various purposes, it is pertinent to understand the environmental impact of this growth and to take necessary steps to mitigate any potentially harmful consequences.

In response to an increase in the number and intensity of wildfires that pose ever greater threats to life and property, the American Institute of Aeronautics and Astronautics (AIAA) issued a request for proposal (RFP) of a responsive aerial firefighting aircraft. The technical project in this portfolio encompasses the design and evaluation of a firefighting aircraft that aims to compete in the 2022 AIAA Undergraduate Team Aircraft Design Competition. Working alongside a team of undergraduate aerospace engineering students, a purpose-built large size firefighting aircraft is designed following a process that is divided into the three phases of conceptual, preliminary, and detailed design. Emphasis is placed on the conceptual design phase, where the feasibility of meeting the requirements with a credible aircraft design culminates in the general size and configuration of the aircraft including the inboard profile and major subsystems. Various design and analysis tools are used, including OpenVSP and NASA's Flight Optimization Software (FLOPS) for the initial configuration as well as computational fluid dynamics (CFD) for analyzing aerodynamic performance. The technical report serves as a proposal submitted to the AIAA competition that includes all relevant aspects and features of the final design configuration as well as documentation of the pertinent analysis and studies supporting the design choices. The proposed design increases effectiveness and lowers the barriers to entry for the organizations tasked with mitigating the wildfire threat both domestically and abroad.

In an increasingly connected society, aviation plays an important role in economic development and social welfare, but at the same time it is a significant contributor to climate change with extensive environmental externalities. With the industry's continued growth, the various stakeholders will need to mitigate environmental impacts more seriously or face significant disruptions and regulatory restrictions in the future. In the STS research project, the wicked problem framework from the study of science, technology, and society (STS) is used to answer the question of how the aviation industry is evolving in response to continued growth that counteracts increased efforts of environmental sustainability. Achieving sustainable aviation is a wicked problem, in part because there is no end in sight, but largely because there is no agreement on what an acceptable solution may be to the multiple heterogeneous stakeholders. While technological, market-based, operational, regulatory, and behavioral changes have all been proposed, there are no unique, clearly best solutions for wicked problems. Nonetheless, it is proposed that behavioral changes on the part of informed consumers have great potential to bring aviation back to a sustainable growth path. This work draws attention to the lack of publicly available information on the problem of aviation’s environmental impact and also the limitations of currently proposed initiatives to mitigate that impact. In tackling the wicked problem of sustainable aviation, it is through reconciling the diverse viewpoints of the many stakeholders that pathways forward can be generated and accepted on a global scale.

Throughout the history of aircraft design, requirements for performance and cost often outweighed environmental considerations, and social implications have been treated as an afterthought of the design process. These two related projects highlight that aircraft design as an engineering practice, and the operation of the aviation industry more generally, does not happen in isolation from the larger societal context, despite that being the historical perspective taken by engineers, industry representatives, and lawmakers alike. The design approach taken in the technical project is enhanced by a more comprehensive understanding of aviation's environmental impacts and the roles of various stakeholders in mitigation. Meanwhile, the STS research benefits from an understanding of the limitations of relying on technological fix approaches, which is gathered from the complexities of designing an entirely new aircraft. Finally, the simultaneous completion of these two projects draws attention to an apparent irony in the development of novel aerial firefighting approaches to combat environmental changes that are brought about partially by the aviation industry to begin with.