Thesis Project Portfolio

AIAA 2022-2023 Undergraduate Hybrid-Electric Regional Turboprop Aircraft Final Design Report

(Technical Report)

The Effects of Visual Aesthetics in Aircraft Design

(STS Research Paper)

An Undergraduate Thesis

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Executive Summary

How can aerospace engineers design a successful aircraft for the future?

With the development of a globalized economy comes the growing need for travel. For the airline industry, this means the extensive use of fossil fuels due to their high energy density and ease of access as a result of the widespread distribution network across the globe. However, the substantial consumption of fossil fuels by airlines has resulted in the increase of greenhouse gas concentration in the atmosphere causing global warming. Furthermore, the cost of fossil fuel has also been rising over the years, and it is expected to rise as low-extraction-cost reservoirs are being depleted at a rapid rate. Therefore, all airlines are facing growing demand for more fuel-efficient commercial aircraft to fulfill the challenges of the future. Nonetheless, designing an aircraft that's both more efficient than the current state-of-the-art and marketable is challenging. Not only because of the engineering difficulties associated with the technologies level of the nest decade, but also because aircraft is a product that involves masterful design in every aspects.

As an aerospace engineering student, my technical project is to design an next-generation hybrid turboprop aircraft for the 2023 American Institute of Aeronautics and Astronautics (AIAA) Undergraduate Team Aircraft Design Request for Proposals (RFP). The aircraft, named Songbird-E, seeks to revolutionize the turboprop market, enabling more efficient and environmentally-friendly air travel by means of electrification. Utilizing a weak distributed electric propulsion (DEP) configuration combined with updated engines, improved aerodynamics, and advanced composites, the Songbird-E finds an overall reduction of 33.6% in

block fuel consumption over a typical 500 nautical mile mission, when compared to the current state-of-the-art ATR 42-600 turboprop aircraft. Attention has been taken to meet other requirements as well, including a 50 passenger capacity, a 1000 nautical mile design mission, a cruise speed of 275 knots at 28,000 feet, and meeting the required take-off and landing field lengths. The Songbird-E also reduces direct operating cost by 14.2%. All assumptions made in the design were carefully considered, and we concluded a viable entry into service year of 2035.

For the STS portion, the focus is on the design aesthetics of aircraft, since within the RFP the AIAA recommends the teams to “make the aircraft visually appealing so it will be marketable." Therefore, I asked “What role, if any, does visual aesthetics play in the design and marketability of an aircraft?” By investigating the traditional theory of aesthetics such as the Gestalt Principles, which attributes beauty to symmetry, proximity, similarity, repetition, continuance, and closure, I was able to use it to examine various existing aircraft and their design languages. In the end, it was concluded that an excellent aircraft, whether it fits the traditional sense of aesthetics or not, could still benefits from the repeated exposure and similarity to its own kind. At the same time, market selection will select the best-performing features, therefore airplanes designed for the same mission will inevitably look the same. This means that in essence, “similar to the successful norm” simply is a synonym to “aesthetically pleasing” in the world of aviation.

Using the Gestalt principle, it can be concluded that our Songbird-E design looks extremely similar to the ATR-42 turboprop. In fact, the only major exterior difference between the two is that our Songbird-E design has four engines (two turboprops inboard, two electricprops outboard) while the ATR-42 turboprop only has two engines (both turboprops). Everything else

ranging from the cockpit to the empennage has a similar appearance. While it is certainly true that the easiest way to achieve an “aesthetically pleasing” design is to just design an aircraft that’s extremely similar in appearance with the current state-of-the-art, it is not the only option. After all, the definition for “aesthetically pleasing” according to the Gestalt Principles does result in a feedback loop to a certain extent, because of attributes such as “similarity” and “repetition” which could be the results of successful designs in general. However, as no aircraft has failed for being too beautiful, designing with good aesthetics in mind would not hurt sales, as long as other engineering parameters are satisfied and the aircraft is good at performing its mission.