AIAA HOMELAND DEFENSE INTERCEPTOR

CORPORATE CULTURE OF BOEING DURING 737 MAX 8 AND 9 INCIDENTS

A Thesis Prospectus
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By
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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

This thesis prospectus will outline two projects, the design of a new homeland defense interceptor aircraft for the United States and an analysis of the struggles of Boeing's 737 MAX 8 and 9 aircrafts. Both of these projects share an underlying goal of helping keep Americans safe in the sky. To keep Americans safe, the United States will need a large quantity of cheap, remotely piloted aircraft for homeland defense. I, along with my project team, will develop a new transonic, remotely piloted aircraft which meets all of the goals and requirements outlined in the American Institute of Aeronautics and Astronautics (AIAA) 2024 Undergraduate Team Design Competition Request for Proposal (RFP). The technical and science, technology, and society (STS) projects are not directly related, but they are analogous cases, both relating to aircraft design and safety of Americans. The STS project outlined in this prospectus involves analyzing many factors which contributed to failures of the 737 MAX 8 and 9 aircrafts. To accomplish this, I will draw on the STS framework of actor-network theory to analyze how a corporate culture at Boeing that valued bottom line before safety led to design choices which inevitably caused hundreds of deaths and almost caused another horrible incident. Actor-network theory will best allow the analysis of all of the inputs that led to this horrible outcome. These are important topics to projects as they address two important pieces of safety for Americans in the aerospace sector. The homeland defense interceptor allows the American people to be safe from American adversaries, but Americans should also be able to feel safe while traveling on civil aircraft, like the Boeing 737 MAX 8 and 9. Because the challenge of American aerospace safety is sociotechnical in nature, it requires attending to both its technical and social aspects to accomplish successfully. In what follows, I set out two related research proposals: a technical project proposal for developing a new remotely piloted homeland defense interceptor and an STS project proposal for examining the corporate culture at Boeing at the time of the 737 MAX 8 and 9 failures.

Technical Proposal

Introduction

The United States' stealth-centric fleet, comprising the F-22 and F-35 aircraft, is projected to retire in the 2030s (Kass, 2024). This fleet has been instrumental in defense missions against increasingly sophisticated and advanced enemy air systems. Addressing this imminent capability gap requires the development of a small, high-performance, cost-effective, and efficient unmanned homeland defense interceptor. The production goal is one thousand units, emphasizing cost minimization and the use of government-furnished equipment to maximize affordability and accessibility.

Escalating global political tensions heighten the risk of aerial attacks on the United States, making the deployment of effective aerial defense technologies crucial for national security (AIAA, n.d.). As the retirement of a significant portion of the current Air Force fleet approaches, innovative air warfare advancements are essential to safeguard the nation's future (Judson, 2024). The homeland defense interceptor is poised to fill this critical role, designed to match and exceed the performance of its predecessors while advancing airspace control and defense capabilities.

Requirements

This project aims to design a next-generation aircraft for the United States military, surpassing the current fleet's capabilities. Key requirements are outlined in the tables below, the most important of which are maintaining a unit flyaway cost below $25 million and effectively performing point-defense interception, defensive counter-air patrol, and intercept/escort missions.

S-F#	Requirement Title	Evaluation Method
S-F1	Unmanned: must be piloted remotely	Electronics and Controls Selection
S-F2	Take off and land safely	Mathematical Analysis
S-F3	Be operable in all weather conditions	Material selection
S-F4	Complete designated missions	Mathematical Analysis

Table 1: System-level Functional Requirements and Evaluation Methods.

The aircraft should meet essential criteria for performance, weapons carriage, and engine specifications, accommodating all required equipment, weapons, and fuel tanks while facilitating maintenance. By meeting and exceeding these standards, the design will enhance homeland defense against intercontinental ballistic missiles and long-range bombers.

S-O#	Requirement Title	Evaluation Method
S-O1	Able to fly at Mach 1.6	Computational Fluid Dynamics
S-O2	Cheaper than $25 million	Financial Budget
S-O3	Service life of 2000+ hours	FEA Fatigue Analysis
S-O4	Possess enough fuel to accomplish missions	Mathematical Analysis
S-O5	Withstand dynamic pressure of 2133 psf	Finite Element Analysis
S-O6	Turn at a rate of 18 degrees/sec at 35000 ft	Stability and Control Analysis
S-O7	Withstand between +7 and -3 g’s	Finite Element Analysis
S-O8	Use JP-8 or Jet-A fuel	Engine Selection
S-O9	Operate on an 8000 ft runway	Engine Selection
S-O10	Subsonic Static Margin ± 10%	Stability Analysis

S-O11	Accelerate 26 ft/s^2	Engine Selection

Table 2: System-level operational requirements and evaluation methods.

Methods

To commence the design phase, the team performed a thorough analysis of contemporary military defense aircraft, specifically examining the Lockheed Martin F-22 and F-35. These aircraft were engineered with a focus on stealth and interception, incorporating “low probability of detection/intercept” features that were pivotal for maintaining air-to-air superiority during the Global Strike Task Force era (Everstein, 2018). Our current objective is to extend this air-to-air dominance, now integrating effective remote functionalities (FAA, 2020). The design framework has been organized into system components: propulsion, avionics, aero-body, structural elements, and integration/testing, ensuring alignment with specified parameters.

The design project involves developing a digital 3-D model of the aircraft, accompanied by an analysis of cost, risk, and the strategic placement of subcomponents such as fuel tanks, payload, engine, weapons, and piloting avionics. Aircraft design inspiration will draw from a wide range of historical and modern references. See Figure 1 below for the preliminary conceptual design of the HDI24 aircraft. These references will include government reports, research studies on aircraft like the F-22 and F-35, specifications of payload and equipment, advancements in emerging technologies, and insights from technical advisors. The model will be created using three design tools. Solidworks will be used to build the 3D aircraft model. OpenVSP will perform basic fluid dynamics simulations for lift and drag analysis. Finally, ANSYS Mechanical will simulate the structural loads experienced by the aircraft.

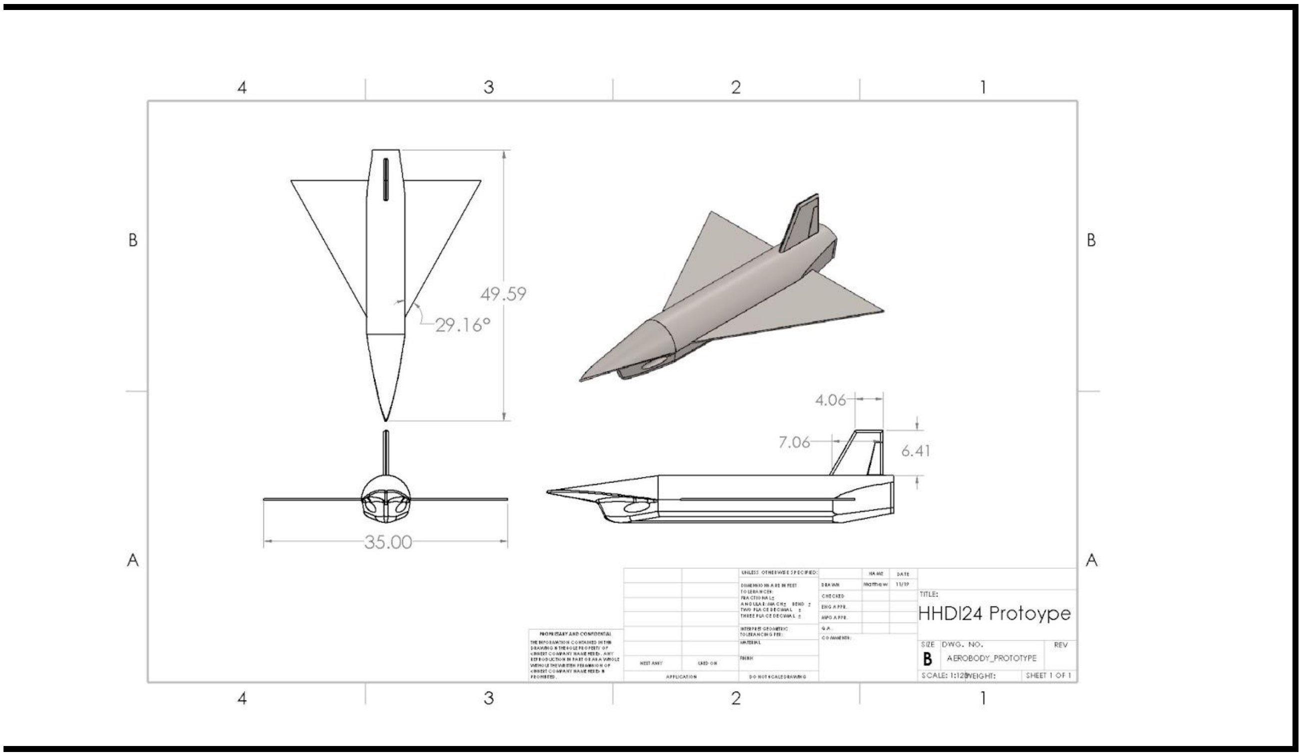

Figure 1: HDI24 Aircraft 3D Conceptual Design created using SOLIDWORKS. [in feet]

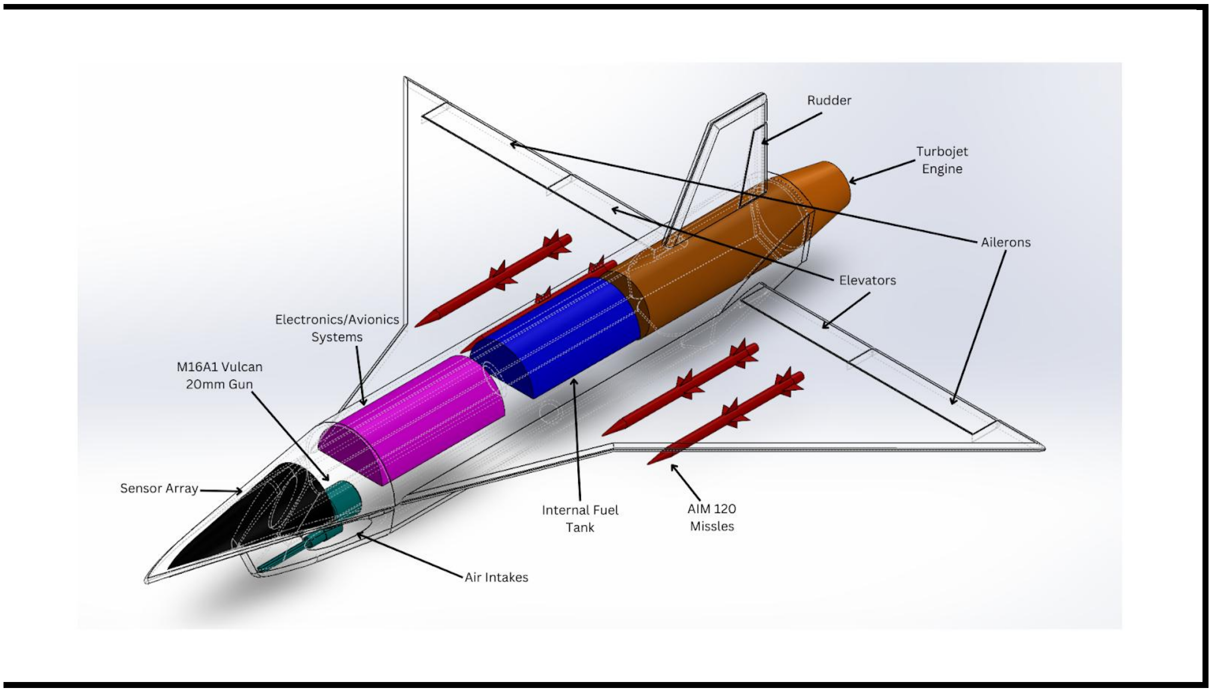

Figure 2: HDI24 Preliminary Internal Systems Design created using SOLIDWORKS.

Team Structure

The team will be broken down into subsystems to divide the work among the team members. The propulsion system will include the engine, intakes, engine mount, and a thermal control system, consuming a significant portion of the mass budget. Avionics will encompass the remote pilot system, weapons deployment, flight control systems, and overall power requirements for the aircraft. The aero-body team will design aerodynamic elements such as the wing, stabilizer, fuselage, intake, and control surface designs. The structural subsystem is responsible for supporting all components and will design the airfoil, fuselage framework, landing gear, payload bay, and maintenance access hatches. Integration and testing will cover the final design development, mass distribution, fuel weight, and maneuverability impacts, non-electric equipment considerations, and overall subsystem integration. These subsystems are interconnected, requiring strong collaboration among team members to achieve seamless performance. With strict design constraints and a limited budget, in-depth analysis of each subsystem component ensures compatibility and cost efficiency. This subsystem-driven approach allows for precise resource management while delivering a comprehensive and cohesive aircraft design.

Proposed Schedule

By the end of Fall 2024, the aircraft's Preliminary Design will be completed. Spring 2025 will focus on finalizing capabilities through processes like the Mission System Integration Review, finalizing the budget, and the Critical Design Review. Comprehensive digital simulations will validate the design, with the final report and 3D model submitted to AIAA by May 16, 2025. Competition results will be announced in August 2025.

On October 29th, 2018, a Boeing 737 MAX 8 traveling from Jakarta, Indonesia crashed in the Java Sea killing all 189 passengers and crew onboard ("Investigation of", n.d.). A few months later, on March 10th, 2019, another Boeing 737 MAX 8 traveling from Addis Ababa, Ethiopia crashed six minutes after takeoff killing all 157 passengers and crew onboard (Sterman, 2023;Ontiveros, 2021). On January 5th, 2024, a Boeing 737 MAX 9 lost a door plug mid-flight roughly 16,000 feet above ground, luckily there were no fatalities (Glanz et al., 2024). Following the two fatal crashes and 346 deaths, all Boeing 737 MAX aircraft were grounded for 21 months which resulted in Boeing losing billions of dollars (Sterman, 2023). The cause of these two crashes was later determined to be the result of a new computer flight control system, Maneuvering Characteristics Augmentation System (MCAS) (Cusumano, 2020). The later issue of the door plug falling off of the aircraft midflight is of a different cause. This issue is thought to be the result of a Boeing subcontractor, Spirit AeroSystems, failing to properly secure the plug, as the recovered plug appeared to be missing critical bolts when found in a back yard (Associated Press and Reuters, 2024; Glanz et al., 2024). Further investigation has found that other aircraft have the same issue, improperly bolted door plugs (Downer, 2024). This suggests serious quality control issues within both Boeing and its subcontractor Spirit AeroSystems.

These repeated issues point to issues internal to Boeing. Boeing, clearly, did not have an adequate verification and validation system to check the work that Spirit AeroSystems did when manufacturing the fuselage of the 737 MAX planes. Furthermore, MCAS was new to the 737 MAX, but Boeing did not explain how MCAS worked in the operations manual, leaving pilots in the dark (Cusumano, 2020). Given that controlling the plane is the job of the pilot, it is questionable that Boeing did not make any mention of this system in the operations manual. The danger of this is further exemplified by Cusumano (2020), "a 2018 Boeing memo also revealed pilots had only four seconds to recognize an MCAS misfire and 10 seconds to correct it" (para. 4). It is thought that the omission of information regarding MCAS is an intentional attempt to make the 737 MAX appear as an incremental upgrade to the old 737 series, which would allow airlines to save millions of dollars on training pilots on new equipment (Cusumano, 2020).

All of these situations point to a culture that places a much greater emphasis on the bottom line rather than public safety. I argue that this poor culture is the reason for the life altering decisions that Boeing made with the omission of information about the MCAS, and the lack of verification and validation of the fuselage supplied by Spirit AeroSystems. To analyze this, I will utilize the science, technology, and society (STS) framework of Actor-Network Theory (ANT). ANT allows a system to be broken down into many different pieces, actors, all centered around a system builder (Law, 1987). These actors can further be broken down into different groups of actors, both human and nonhuman, and we can see how all these actors affect the network. This allows one to more easily see the complexities of the system (Cressman, 2009). I will use ANT as a method to analyze the network that is the Boeing 737 MAX, and I will show that the poor culture at Boeing facilitated the problems with the MCAS and door plugs.

Conclusion

In this prospectus, I have covered my technical project, the AIAA Homeland Defense Interceptor, and my STS project investigating the corporate culture at Boeing which led to the design flaws in the 737 MAX 8 and 9. This investigation into the culture at Boeing will be aided by the STS framework of ANT which allows the for a better analysis of how the individual actors behave with each other inside of the individual network, as well as how they individually affect the network. Lastly, the Homeland Defense Interceptor plans to improve on current designs by being cheaper to manufacture while also being safer due to being remotely piloted.

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