Undergraduate Thesis Prospectus

Designing an Innovative Light Attack Aircraft

(technical research project in Aerospace Engineering)

The Joint Strike Fighter and the Failure of Cost Accountability in U.S. Military Contracting

(sociotechnical research project)

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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General Research Problem

How do military aircraft design priorities evolve in relation to advances in aeronautics and political influence?

The United States Air Force has been a dominant force in combat aircraft design and innovation. Their latest production aircraft, the F-35 Lighting II Joint Strike Fighter, is a fifth-generation aircraft that utilizes the latest technology to fulfill its multi-role mission (Lockheed Martin, 2020a). The Joint Strike Fighter was developed to replace many of the aging aircraft platforms currently utilized by the Air Force (Tegler, 2018). However, throughout its development the program has been heavy criticized by the press (Insinna, 2019) and the Government Accountability Office (Ludwigson, 2020) for its trillion-dollar price tag and years of delays in comparison with the previous generation aircraft it seeks to replace. For close air support, the more affordable A-10 Lightning II retains support among lawmakers and is difficult to replace, despite its aging platform (Pawlyk, 2020). The Air Force has struggled between supporting aging but effective platforms while developing innovative but costly new ones. It has thereby attracted criticism from lawmakers and taxpayers.

Designing an Innovative Light Attack Aircraft

How can we design an affordable light attack aircraft to provide close air support to ground forces in missions that are currently only feasible with attack helicopters?

As an Aerospace Engineering undergraduate with the MAE department, my technical capstone consists of an aircraft design challenge under the guidance of Professor Jesse Quinlan. In this challenge, my team of seven is presented with a series of requirements from the American Institute of Aeronautics and Astronautics (AIAA) that must be met by our aircraft

design, which will be submitted to an AIAA competition. The seven members are listed as collaborators on the title page of this document.

The Fairchild Republic Co. A-10 Thunderbolt II is a cold-war era close-air-support (CAS) attack aircraft that has been in service for the U.S. since 1976 (Military.com, 2020). However, the A-10 is showing its age, as evidenced by a $1.1 billion contract Boeing received in 2007 to replace the wings of 173 aircraft (Lloyd, 2019). Despite the U.S. Air Force's attempts to phase it out in the last three years, so as to free budget and maintenance for new aircraft like the F-35 Joint Strike Fighter, the A-10 has remained in service due to its support with lawmakers (Pawlyk, 2020). Providing a viable and competitive alternative to the A-10 and the expensive F-35 would be a major step towards convincing lawmakers to budget for a new CAS aircraft to replace the aging A-10. This can already be seen with the likes of the Embraer A-29 Super Tucano, which is seeing support in Congress for its affordability and durability (Osborne, 2020). With this project, we hope to provide a compelling aircraft design that would allow the Air Force a chance to affordably modernize their fleet with the support of lawmakers who prioritize reliability and cost.

The project, designed to satisfy an AIAA Request for Proposal, has well-documented constraints that guide our team towards our goal of a practical and affordable light-attack aircraft design. These constraints consist of required performance metrics as well as objectives to consider (fig. 1). In addition to these itemized general requirements, there exist two unique constraints to consider. First, there are two mission outlines that our attack aircraft must be able to execute: a design mission, focused on a standard attack operation, and a ferry mission, describing a long-range transfer of payload and crew (fig. 2). Second, all technologies utilized in

our design must be at a Technology Readiness Level (TRL) of 8 by 2025, which means that they are flight-proven and operational as opposed to developmental technology.

General Requirements

The requirements and objectives below are applicable to both aircraft within the family.

- [R] Austere Field Performance: Takeoff and landing over a 50 ft obstacle in ≤ 4,000 ft when operating from austere fields at density altitude up to 6,000 ft with semi-prepared runways such as grass or dirt surfaces with California Bearing Ratio of 5
- [O] Survivability: Consideration for survivability, such as armor for the cockpit and engine, reduced infrared and visual signatures, and countermeasures (chaff, flares, etc.).
- [R] Payload: 3000 lbs of armament
- [O] Provisions for carrying/deploying a variety of weapons, including rail-launched missiles, rockets, and 500 lb (maximum) bombs
- [R] Integrated gun for ground targets
- [R] Service life: 15,000 hours over 25 years
- [R] Service ceiling: ≥ 30,000 ft
- [R] Crew: Two, both with zero-zero ejection seats

Figure 1: Itemization of the general requirements and objectives for the aircraft design (AIAA, 2020)

Design Mission

The design must be capable of performing the design mission outlined below with the full payload requirement.

1	Warm Up / Taxi	5 minutes
2	Take Off	Austere field, 50 ft obstacle, ≤ 4,000 ft
3	Climb	To cruise altitude, ≥ 10,000 ft; with range credit
4	Cruise	100 n mi
5	Descent	To 3,000 ft; no range credit; completed within 20 minutes of the initial climb
6	Loiter	On station, four hours, no stores drops
7	Climb	To cruise altitude, ≥ 10,000 ft; with range credit
8	Cruise	100 n mi
9	Descent / Landing	To austere field over 50 ft obstacle in ≤ 4000 ft
10	Taxi / Shutdown	5 minutes
11	Reserves	Sufficient for climb to 3,000 ft and loiter for 45 minutes

Ferry Mission

The design should also be analyzed for a long-range ferry mission including full crew and 60% of the payload requirement.

1	Warm Up / Taxi	5 minutes
2	Take Off	Austere field, 50 ft obstacle, ≤ 4,000 ft
3	Climb	To cruise altitude; with range credit
4	Cruise	At best range speed / altitude (≥ 18,000 ft), 900 n mi
5	Descent / Landing	To austere field over 50 ft obstacle in ≤ 4000 ft
6	Taxi / Shutdown	5 minutes
7	Reserves	Sufficient for climb to 3,000 ft and loiter for 45 minutes

Figure 2: Two mission overviews to be feasible for the aircraft design (AIAA, 2020)

The state of the art of attack aircraft design is highly relevant to this project, made evident by the constraint on our design to use flight-proven, operational technology at TRL 8. As such, much of our research focuses on current attack aircraft platforms that are currently operational. The Embraer A-29 Super Tucano stands out as the current production aircraft most fitted to the design laid out in the design challenge. With over 320,000 flight hours and over 220 aircraft delivered (Embraer, 2020), while also boasting a per-unit price of approximately $11 million (Aircraft Compare, 2020), the A-29 is a proven and effective platform for providing affordable close air support from austere airfield conditions. However, other aircraft have advantages that would be helpful to consider for creating a solution that improves on what the A-29 already delivers. The Fairchild Republic Co. A-10 Thunderbolt II is a twin-turbojet attack aircraft designed in the 1970s that is also renowned for its effectiveness in its role. While an older and more expensive platform, with a unit price of about $18.8 million, its use of turbojet propulsion allowed for excellent maneuverability at low air speeds and altitude while also operational from austere conditions (Air Combat Command, 2015). The Lockheed Martin F-35 Lightning II, while designed to be a multi-role attack fighter, is a poor choice for an affordable attack aircraft due to its unit-cost nearing $100 million (Tegler, 2018). However, as one of the most technologically advanced aircraft to date, it has features worth researching that could provide an edge over the older A-29 and A-10 while still fulfilling the TRL 8 requirement, such as stealth and advanced radar (Lockheed Martin, 2020b).

To develop a design solution for this project, our team will perform a series of analyses to iterate and perfect a final aircraft design. After initial research into attack aircraft design, our team selected an optimal set of design parameters from a series of initial configurations developed by each member, which was then refined into a single aircraft design. We then will

perform systems, cost, and aerodynamic analyses to refine the design throughout the remainder of the project. It is likely that we will be using modeling software and computational fluid dynamics to simulate and test our design. By the end of the project, we will have developed a light attack aircraft design that has been validated to meet each of the constraints, predicted to have a competitive cost, and designed to have improved on existing light attack aircraft in service today.

The Joint Strike Fighter and the Failure of Cost Accountability in U.S. Military Contracting

How has the Joint Strike Fighter program's exorbitant cost and controversy revealed weaknesses in cost accountability of U.S. military contracting?

The concept of a Joint Strike Fighter program has existed since 1996 with the purpose of replacing a combination of air-superiority and attack aircraft, including the F-16, A-10, F/A-18, and AV-8B Harrier (Tegler, 2018). The F-35 Lightning II multi-role fighter is the result of decades of development, years of delays, and billions of dollars. The Government Accountability Office estimates the program costs as of 2019 at $430 billion, which is more than $190 billion more than the 2001 base estimate (Ludwigson, 2020). Despite the increased project costs, all three variants of the F-35 have entered into full production at less than $100 million per plane (Tegler, 2018), and are being delivered to the US armed forces and partner nations (Gertler, 2020). The response to the 1996 challenge has become a prominent illustration of controversial deficiencies in U.S. military contracting. The Department of Defense has overseen the development of the F-35. Its Joint Program Office is its liaison with industry partners (ESD, 2020). The Government Accountability Office is an independent, nonpartisan agency working fort Congress that explores the use of taxpayer dollars, including spending on the F-35 program

(GAO, 2020). The GAO is often critical of the F-35 program, claiming in 2019 that the program "is not meeting standards aimed at ensuring consistent, high-quality products" and that the aircraft "do not meet reliability goals" (Ludwigson, 2020). Lockheed Martin has been responsible for the F-35 design and production since winning the Joint Strike Fighter competition in 2001 (Lockheed Martin, 2020b). Members of Congress remain influential in the F-35 program. In March 2020 a letter of support garnered endorsements from 130 Representatives (Larson et al., 2020). On behalf of the representatives, Larson claimed that the F-35 is "the most advanced fighter in the world and is exceeding operational expectations," and is supporting 98 new aircraft in the Fiscal Year 2021.

Researchers have studied the Joint Strike Program. The Congressional Research Service produced a report on the F-35 development to inform legislators about the program history, costs, status, and goals (Jeremiah, 2020). Petrelli (2020) studied how the F-35's capabilities reflect modern approaches to defense acquisition and innovation. Vucetic and Nossal (2012) studied the international politics of the F-35 program as the largest weapons program in modern history. Adams (1981) attributed high cost overruns among defense contractors to a mutually beneficial relationship between contractors, the Executive Branch, and Congress: the "iron triangle." The triangle excludes outside perspectives and impairs the accountability of all three of its legs. Joyce and Blankenship argue that overseas defense spending, or "strategic spending," carries risks to local economies, U.S. interests, and hidden costs, which can contribute to unwanted consequences (2020).

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