Light Attack Aircraft Design Proposal
(Technical Paper)

The Growing Priority of Sustainable Design, and the Engineer's Role in Promoting a Sustainable Future
(STS Paper)

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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

Introduction:

When developing technologies for military use, reactive problem-solving is a death sentence. Take the US Department of Defense, who in the late 1970's realized the need for a new aircraft capable of long-range, high-speed troop transport and vertical takeoff. The realization of such a need in the US arsenal was made shockingly evident during the failures of Operation Eagle Claw, the botched mission to extract hostages from the US Embassy in Iran, which cost eight American servicemen their lives without the enemy firing a single shot (Ball, 2012). To be able to respond to any crisis imaginable in an ever-evolving theater of war, militaries must continually innovate to address problems before they arise, a doctrine exemplified in the need for a new affordable light attack aircraft for the US military. From aircraft like the A-10 Thunderbolt II to the very concept of an attack helicopter, nearly all aircraft currently in service with the US military utilized to perform close air support (CAS) missions have their design roots in the Cold War, a time when every military development by the US was framed around a potential all-out global conflict with a comparable superpower in the USSR (Schlight, 2003). Predictably, such doctrines are mostly irrelevant to a modern battlefield dominated by counterinsurgency, operations centered around long periods of waiting punctuated by rapid bouts of combat, frequently in remote corners of the globe (Bureau of Political-Military Affairs, 2009). This technical project aims to respond to a Request for Proposal (RFP) for an affordable light attack aircraft capable of short takeoffs and landings while operating in austere conditions near the front lines, under the mindset that such an aircraft would be capable of assuming many of the mission types currently only performable by attack helicopters (AIAA, 2020). Deliverables for this technical project will include a complete design plan and both performance and cost breakdowns for such a light attack aircraft.

When looking at designing an aircraft for military use, there are numerous different factors and considerations which must be analyzed and weighed against one another. Sustainability, however, is rarely included as one of these important factors. While environmental considerations have grown in relevance in recent years, such a focus is still generally a priority only in a select few industries, and not ubiquitous across the broader engineering field (Gagnon et al., 2010). By the nature of their work, engineers are required to provide a solution that fulfills all the listed deliverables from the client or problem statement, but this has led to questions over whether the duties and societal responsibilities of the engineer go beyond these baseline requirements. The proposed sociotechnical analysis will explore what role engineers have in guiding the planet to a more sustainable future, and how they are empowered, or hampered, in fulfilling such duties.

Technical Topic:

The United States Armed Forces currently utilizes several primary platforms to perform ground attack and close air support (CAS) operations. In this modern context, CAS is defined as "air action by fixed-winged and rotary-winged aircraft against hostile targets that are in close proximity to friendly forces and that require detailed integration of each air mission with the fire and movement of those forces" (USAF, 2020). Such operations can be both offensive or defensive, and by their nature tend to put the aircraft directly into dangerous situations. Looking at fixed-winged aircraft which see mainline use, the A-10 Thunderbolt II is perhaps the most recognizable dedicated CAS platform, while legacy aircraft such as the F-15 and F-16 are also commonly utilized in this role (Kaaoush, 2016). While these platforms are capable of carrying high volumes of payload and can far outperform standard tilt-rotor or vertical-rotor craft in typical aircraft performance metrics such as speed, range, and service ceiling, they are limited by several crippling factors in regards to the mission profile specified in the RFP. They require more runway space and developed terrain to operate than a helicopter, but the most glaring difference is the cost. Of the three aircraft listed previously, the A-10 is the cheapest to operate and usually considered the best at performing CAS missions, but even the A-10 costs approximately $20,000 per flight hour to operate, an expensive price tag when not all launches even result in an engagement. On the other hand, attack helicopters like the AH-1 Cobra and AH-64 Apache are far more suitable for rapid deployment in all manner of austere and rough conditions, as their turboshaft powerplants allow for vertical takeoff and landing. Like fixed-wing ground attack aircraft, helicopters can be outfitted with a variety of different surface-to-ground weaponry depending on the mission, but where helicopters fall significantly short is in survivability. A combination of slower operating speeds, poor handling, and low altitude flight leading to close proximity to hostile forces means that helicopters are a far more fragile CAS platform compared to comparable fixed-wing aircraft (Kopp, n.d.). Such shortcomings are why a key focus of this design project is improved survivability relative to existing helicopters, while still being able to fulfill missions currently only feasibly done by helicopters.

As stated in the RFP, the objective of this technical project is to design an affordable light attack aircraft capable of performing CAS operations from short, austere fields, serving as a viable alternative and eventual replacement for existing ground-attack helicopters. To achieve this objective, the design team will first study existing light attack aircraft currently in service, analyzing how these current platforms compare to the mission parameters and performance metrics designated in the RFP. Team members will then devise a series of potential initial configurations for a light attack aircraft design, which will then be tested and compared against one another to iterate towards a suitable initial configuration. The team will continue to refine this design throughout the process, as different exercises in weight estimation, aerodynamic analysis, flight handling, and cost breakdown are conducted to provide justification for existing or new design decisions. These iterations will lead to a final design configuration, which will be submitted to the AIAA 2021 Undergraduate Aircraft Design Competition by the May 2021 deadline, along with accompanying graphics and write-ups.

STS Topic:

As massive as the Earth may seem, it does not possess infinite resources, and humankind is consuming those resources at a far greater rate than can be naturally replenished. The historic rates of resource consumption and indifferent attitude towards the planet's long-term health over the past few centuries have put society in a position where massive changes are necessary to preserve the earth's well-being. One can start with the planet's rising temperatures; the mean temperature of the earth has risen by an entire degree Celsius relative to the 1951-1980 average temperature, with 19 of the 20 hottest years of all-time happening since 2001 (Shaftel, 2020). Or one might choose to consider fossil fuel consumption, where some estimates place the expiration date for the Earth's oil reserves at 2052, and that of coal at 2090 (Kuo, 2019). There is significant guesswork and assumptions that go into such numerical estimates, and these predictions can be easily framed or presented such as to push a particular agenda. That being said, what cannot be debated is that modern society will not be able to sustain these consumption levels indefinitely, and that deliberate, targeted, and drastic changes must be made and adopted globally to curb these trends. As much as any action or governmental policy, such wholesale changes as to how people think and interact with the environment is equally dependent on people themselves changing their mindsets and view on sustainability, and the realm of engineering is no exception.

In order to understand what role and responsibility engineers play in promoting a sustainable future, it is important to first understand what sustainable engineering is, and how it differs from the "traditional" view of engineering. For the purposes of this investigation, sustainable development will be viewed under the working definition of "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (World Federation of Engineering Organizations', 2002). Such a definition is broad by design, and allows for the full spectrum of sustainability to be analyzed, not simply specific environmentally friendly technologies or practices. Prioritization of sustainable engineering starts at the very beginning of an engineer's upbringing, as both educational and greater cultural influences have a pronounced effect on the mindset and attitude of a person, both within and outside of one's professional career (McIsaac & Morey, 1998). To understand the role that engineers *should* play in pursuing a sustainable future outside the rigid boundaries and deliverables of work projects, one must have a firm grasp on the education engineers receive, and how they are taught to address topics like sustainability. In general, there are two main schools of engineering practice: traditional engineering and sustainable engineering, and how these two approaches are presented against and in conjunction with one another by educational facilities, higher institutions, and mentors play a pivotal role in shaping the engineer's worldview and their perceived responsibilities within that worldview (Mulder, K.F. et al., 2012). How these views on engineering have changed in modern times, along with what explicit and implicit duties the common engineer has to enforce such practices, will be key points of investigation within the proposed analysis.

To answer this multilayered research question, the primary STS framework utilized will be paradigm shift framing. The idea of the paradigm shift framework was first put forth by philosopher Thomas Kuhn, and the core principle of this framework centers on great shifts in accepted concepts and angles of viewing the world (Kuhn, 1962). Such shifts, during which established norms and frames of view are significantly revised and altered by a new understanding in the field, result in a new prevailing paradigm. A classic example of a paradigm shift is the Copernican Revolution; for centuries a geocentric model of the universe had been the consensus "right" view, but through the works of Copernicus and others, this model was challenged and ultimately replaced by the new paradigm of a heliocentric model, which has been the basis for all scientific exercises since (Spencer, 2020). While paradigm shift is an appropriate framework for this investigation, as general engineering and industry practices have shifted from the traditional view to a more sustainable view, critics of the framework are quick to point out that paradigm shift theory can tend to undersell the validity of scientific knowledge, instead subscribing to the mindset that such facts are nothing more than opinions heavily swayed by whatever viewpoint or mindset is most prevalent at that time (Cohen, 2015). These criticisms will be duly considered, but nevertheless, the paradigm shift framework will provide a strong foundation from which to explore the changing perception on sustainability in the global and local context.

Methodologies:

Research Question: What responsibilities do engineers have in guiding the world towards a sustainable future?

To explore this research question, several methodologies will be incorporated into the investigation. Documentary research methods will be a driving force for analyzing the history of sustainability and its evolving relationship with engineering practices. Existing literature and investigations into sustainable engineering will illuminate the various influences and factors which play a role in determining the engineers’ responsibilities with regards to sustainability, from the impact of education to considerations of public policy and the tools higher institutions currently provide, or fail to provide, which allow engineers to fulfill these duties (UN Educational, Scientific, and Cultural Organization, 2020). Such research will help answer the question of what exactly the role of the engineer is in building a sustainable future, and how both local and global factors have caused this role to evolve.

In addition to this methodology, both wicked problem framing and historical case studies will be incorporated into the analysis of the research question. Issues centered on complex problems like environmental sustainability are dynamic and convoluted challenges to tackle, with a bevy of different and contradicting influences at play simultaneously. Wicked problem framing will assist in breaking down such an overwhelming problem into more manageable areas of research, in order to explore the problem through different lenses including economics and public policy. Historical cases will also be analyzed during the investigation as applicable. An example of one such historical case is the Volkswagen emissions scandal, where Volkswagen deliberately designed automobiles which emitted pollutants in excess of legal limits, but falsified data so the vehicles still passed environmental testing (MacDuffie, 2019). Such case studies will provide valuable context to the role of engineers in promoting sustainability, displaying pertinent examples of this evolving role, or the lack of it, in practice.

Conclusion:

As modern military operations have shifted towards a focus on counterinsurgency operations, the shortcomings of modern CAS platforms have come into clearer focus. Most fixed-wing platforms have become too expensive to continuously operate in the necessary manner, while helicopters have their own pressing concerns in survivability and attack range. As such, the aim for the technical project is to design a new light attack aircraft to fulfill CAS missions, one which can accomplish mission types currently only feasible with helicopters while improving on the survivability concerns inherent to helicopters. The deliverable for this project will be a complete design and breakdown of a light attack aircraft, including properties such as geometries, performance graphics and characteristics, and cost and maintenance schedule for the proposed aircraft.

In evaluating the viability of the above-mentioned aircraft design, while costs are a driving success metric, sustainability concerns are notably absent from the RFP. While some of this absence can fairly be attributed to the military nature of the project, it still brings to light the discussion of the engineer's role in sustainability. As environmental and sustainability-oriented practices and goals have risen in global importance, so to have the perceived responsibilities of people to actively work towards such goals, and engineers are no exception to this trend. This research will aim to explore what roles the engineer has in guiding the world towards a sustainable future through their work, and analyze the tools and teachings given to engineers in support of this goal.

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