DESIGNING THE FIREFIGHTING AIRCRAFT OF THE FUTURE

TAXATION WITHOUT DISSATISFACTION: GARNERING PUBLIC SUPPORT FOR AIRCRAFT DEVELOPMENT

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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As the planet gets warmer and dryer due to climate change, so too increases the amount of potential fuel for a wildfire (Center for Climate and Energy Solutions). Although the net quantity of wildfires in the United States has decreased over the past 30 years, the acreage of land affected has increased (Hoover & Hanson, 2021, p. 1). Thus, modern firefighting techniques need to be improved to counteract this growing issue, and one such method for doing so is aerial firefighting. Aircraft can be used to fight fire in strategic ways, as well as offensively in wildfire suppression. The technical project entails designing a large airtanker meeting the criteria of the Request for Proposal (RFP) set forth by the American Institute of Aeronautics and Astronautics (AIAA). The research and development put into this design will be conducted as a team, consisting of fellow students LeeYung Chang, Matteo Harris, Aaron Hyunh, Del Irving, Christopher Kwon, Jason Le, and Andrew Wheatley, under the advice of Professor Jesse Quinlan of the Department of Mechanical and Aerospace Engineering. The STS project, under the advice of Professor Catherine Baritaud of the Department of Engineering and Society, is an individual exploration into the issue of mobilizing public interest for funding of aerial firefighting technologies, examined through the lens of Actor-Network Theory (ANT) (Law & Callon, 1988). Below, Figure 1 depicts a Gantt chart for the anticipated schedule for completion of both the technical and STS portions of this thesis project.

Task Name	**Sep 21**	**Oct 21**	**Nov 21**	**Dec 21**	**Jan 22**	**Feb 22**	**Mar 22**	**Apr 22**	**May 22**
System Requirements Review									
State-of-the-Art report									
Initial takeoff gross weight calculation									
Configuration trade studies									

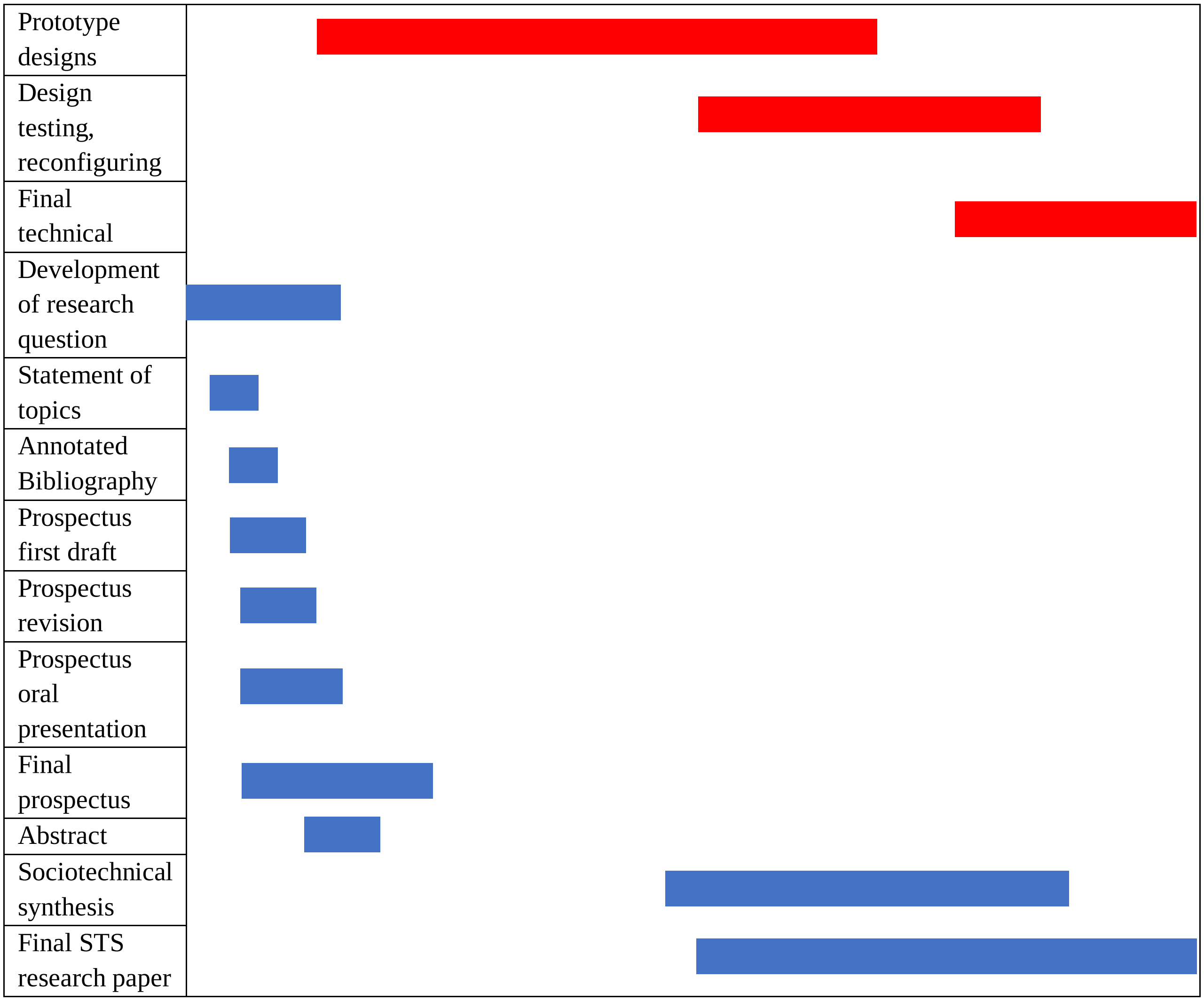

Figure 1: Gantt chart depicting timeline for completion of the thesis project, red relating to the technical report and blue to the STS research paper. Prospective timelines are still flexible, with the stipulation of being complete by May of 2022.

DESIGNING THE FIREFIGHTING AIRCRAFT OF THE FUTURE

The current landscape of design for firefighting aircraft is most aptly characterized as bleak. When thinking of the cutting-edge development of aircraft technology, one's mind immediately gravitates toward military applications, which is unsurprising considering the current budget for the Department of Defense (DOD) is about $1.5 trillion (USAspending, n.d.). For reference the Department of Agriculture (USDA) is allocated about a third of this amount, just shy of half of a trillion dollars (USAspending, n.d.), $1.01 billion of which has been set aside for investment into wildfire suppression technology (United States Department of Agriculture, 2021, p. 86). When making a further comparison to The Boeing Company's (2021, p. 62) spending on research and development alone, a quantity of about $2.5 billion, it is clear there is a dearth in funding which has left the aerial firefighting landscape decades behind commercial and military aviation. The lack of funding has necessitated that the current aircraft deployed in wildfire management are now-defunct commercial and military aircraft, refurbished to suit the firefighting mission (Iannotta, p. 2, 2014). As such, the goal of this technical project is to meet the technological deficiencies of current outdated models by proposing a next-generation aircraft for firefighting application, while meeting the criteria of the Request for Proposal (RFP) set forth by the American Institute of Aeronautics and Astronautics (AIAA). As part of understanding these criteria, a mission profile as modelled in Figure 2 below is critical in informing design decisions, the metrics used in trade studies, and the calculations made for configuration.

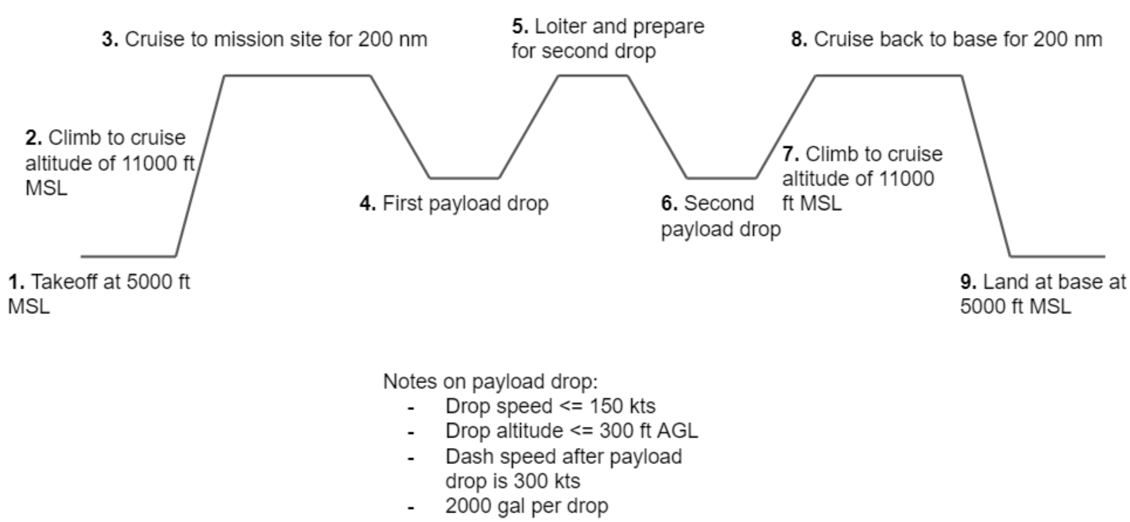

Figure 2: Mission profile for the multi-drop-capable airtanker, constricted by the requirements of the RFP.

In order to establish a framework upon which improvements can be made leveraging breakthroughs in modern technology. As such, analysis of an existing aircraft in the large airtanker category, such as the Douglas DC-10 (*Firefighting Aircraft Recognition Guide*, p. 5), provides insight into how current models in the field are configured. Members of the design team construct aircraft designs using modelling software like OpenVSP (McDonald, 2016), from which initial estimates of takeoff gross weight can be drawn. Establishing this quantity opens the door to further configuration of design features of the aircraft which are divided into several categories, with a member of the design team tasked focusing on a select aspect: operations, aerodynamics, structures, propulsion, anti-icing, autonomous systems, federal guidelines, and cost-modelling. Each member of the group returns to the group with an analysis of the potential avenues for design, from which more refined decisions can be made to constrict aircraft configuration.

Besides OpenVSP, other computer-aided design (CAD) or finite element analysis (FEA) software can be used to test the structural components of the aircraft. The aircraft design laboratory is also available for testing and configuration analysis, using common aviation tools like wind tunnels, as well as actual production with 3D printers. With these tools and software at the disposal of the team, the goal is to have a completed design meeting the objectives of the RFP by the end of the Capstone course, which has been approved by the technical advisor Professor Jesse Quinlan of the Department of Mechanical and Aerospace Engineering. Not only should the requirements of the challenge be satisfied, but the aircraft should also embody the classification “next-generation” with sufficient application of modern techniques, while still be ready for production by 2030. The final deliverable will be a written proposal, containing a detailed model of the aircraft, the various design choices made and the reasoning behind them, and a persuasive argument of why the design should be chosen by the AIAA.

TAXATION WITHOUT DISSATISFACTION: GARNERING PUBLIC SUPPORT FOR AIRCRAFT DEVELOPMENT

In introducing the aim of the technical project, the chasm in aviation technology funding provided to the DOD as compared to the USDA was revealed, an observation which begs asking where this money is coming from, and how the gap can be bridged. Clearly, the need for an improvement in funding exists, highlighted by the statistics regarding the increasing damage done by wildfires in the past 50 years (Hoover & Hanson, 2021, p. 1). Even so, the matter of gaining the required funding involves galvanizing the project's benefactor, who in this case is tax-paying citizens. A person's money is of significant personal value to them, and convincing someone to hand it over to their government is no simple task. For instance, in California there is controversy regarding the increase in taxation levied on the population of the Central Valley in order to accommodate the need for firefighting technologies to be funded (Tonarelli, 2021). In contrast, when looking at a community in Colorado, Carlton (2021) found activist groups specifically working against housing development in order to support a safer wildfire infrastructure, despite this hindering the economic progress of the city. Is the matter of importance here how directly the individual feels the money from his pocket is being taken to accommodate a community need? What sorts of action are the public willing to take, and why? When considering at even greater depth the issue of firefighting aircraft, one thinks of the danger facing the firefighter's themselves. This is of specific concern when the aircraft are as old and well-used as the current airtankers are, a problem which cannot be mended without an increase in funding (Wood, 2014). Clearly, the safety and wellbeing of firefighters is another factor in the complex decision-making process behind aviation funding in this field, but to what extent the public realizes this relationship is unclear. Taking a further step back and just looking at the government funding process in general, it is clear that a complex network of individuals and groups decide the distribution of funding, of which the public is just one component (USA.gov, 2021). As such, when considering how to mobilize funding toward an issue like using aviation to fight fires, it can be difficult to pinpoint where exactly in this network to devote efforts.

Therefore, rather than seek one specific deficiency, it is valuable to adopt an approach which considers that agency in the matter of allocating funding for firefighting aviation is diffused across this entire network. Given this realization, the STS framework of actor-network theory (ANT) is best-equipped for analysis of the relationships involved in allocating funding to wildfire management via aircraft, which is depicted in Figure 3. A network metaphor as outlined by Law and Callon (1988) can adequately encompass the various actors involved in government spending decision-making, and how they are interrelated. The aim is not only to understand the actors, their motivations and potencies within the network, but also the unintended consequences of the make-up of the network.

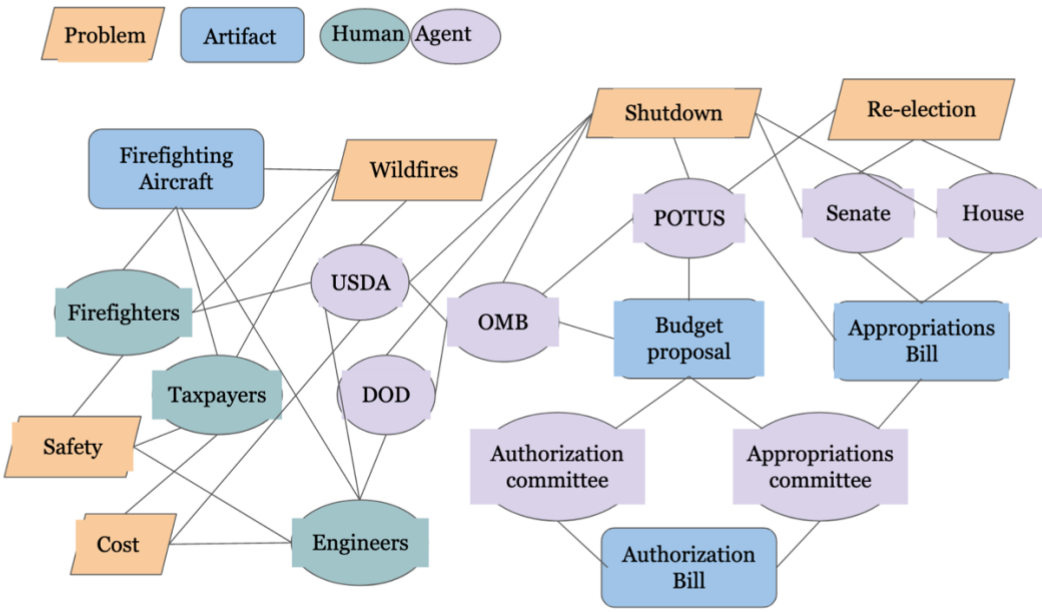

Figure 3: Actor-Network for aerial firefighting funding. Purple agents are those which are internal to the federal government, while green agents are those external to the government. They are still, however, related to government actors within the network.

Such consequences can be due to a lack of dispersal of communication between actors within the same network (Jolivet & Heiskanen, 2010) and the failure of a network to establish a negotiation space through which communication can be facilitated (Law & Callon, 1988). Given the convoluted government agencies and representatives, it is quite easy to imagine conflicting information arriving to the public from various sources, each informed by their own biases and motivations. Therefore, part of the issue in acquiring public funding clearly becomes establishing such a reliable space for negotiation to ensure all the pertinent information is available and in the mind of the citizen when they move to support fundraising efforts for firefighting aircraft.

WHO REALLY SPENDS THE DOLLARS IN OUR POCKETS?

The question confronted by this framework surrounding the funding crisis in wildfire aviation technologies is this: who decides where the money goes, and on what grounds? Who knows the money is going there, and what agency were they capable of exerting to get it there, or try to keep it from getting there? As an engineer, the motivations are simple, the criteria for completion are neatly prescribed by the contractee, the AIAA. Decisions are informed by cost, by efficiency of operation, and by their ability to suit the needs of the client, and a tunnel vision toward these goals is often adopted. In reality, these engineers operate within an intertwined network, which functions in many ways to affect the engineer's decision-making process, even without their awareness. Clearly climate change, and the wildfire crisis stemming thereof, are serious issues demanding public attention, and yet somewhere in this convoluted network their lies a lapse in communication. Adopting an ANT perspective allows for an unbiased, birds-eye view of all the actors at play, to help unravel the nuances which lead to issues of funding for critical disaster response services like those demanded of the Forest Service.

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