Thesis Portfolio

Corvus: Urban Air Mobility Solutions for Package Delivery
(Technical Report)

The Potential Effects of Unmanned Aerial Systems and Urban Air Mobility
(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science, School of Engineering

Jamal D. Parker
Spring, 2020

Department of Mechanical and Aerospace Engineering

Table of Contents

Sociotechnical Synthesis

The technical portion of the thesis is my team's response to a NASA challenge for university students. This year's challenge was to design a UAS that could deliver light packages in a small radius around a distribution center. Many private companies are talking about developing such a service, however the FAA has yet to approve any autonomous UAS services such as the one required by this challenge. NASA and the FAA are currently working together, along with the private industry attempting to offer these services, to develop a UTM system that will make such a service safer. This challenge explicitly requires that we describe how our UAS solution would fit into such a system, and I was the team member responsible for explaining that. Through my research into the FAA and NASA's efforts into this UTM system, I found that it was currently in testing and that many emerging industries are under the understanding they will start getting clearance for their UAS systems in the upcoming years.

Through this research is where the core of the STS report was formed. As a member of a team attempting to design a vehicle for this task and realizing how hard it was to design something that flies over people safely, I became wary of the upcoming ideas I was researching such as Uber Elevate. Additionally, as the technical project moved on, we found that the safer we made our UAS, the more expensive it became to produce exponentially. Research into this and decisions made to reduce cost and redundancy led to the question of how other companies would deal with such a problem. The UAS for small package delivery, though expensive, are expected to pay for themselves over their lifetimes due to the exorbitant price of the 'last mile' in delivery. However, for Uber's eVTOL craft they are developing, will they be hundreds of thousands or millions of dollars a piece with all the newest sensor equipment, and then the price to use them is very high? Or do they cut corners in some places in order to make the rides cheaper yet profitable?

The STS section of this thesis likely would not have come about had I not been on the specific teams I was on for the technical portion of the thesis. The fact that I was on the team for both the FAA drone regulations, the UTM system, and the craft sensors gave me a great sense of interest and insight into what makes these safe, and what makes them expensive. Had I been on the propulsion team for instance, the motors and propellers, though complex, are neither expensive nor likely to break. They are an integral part of the craft, however doing research into them would not have led me to think as much about the STS merits of UAM outside of perhaps noise issues.

For the technical report, my team designed a fully autonomous UAS that we called the Corvus drone. The UAS is a fully electric, vertical takeoff and landing, dual tilt-wing canard. The drone cruises at 70 miles per hour, has a 30-mile range, and is a little over 100 pounds when loaded with the package. We designed this drone with the specific purpose of getting from the takeoff location to the delivery location and back as fast as possible using as little energy as possible, and within the rules of the competition. The final criterion was part of the inspiration for the dual tilt-wing idea. We knew we wanted to use VTOL because NASA required we reach 500 ft within a mile of takeoff, however for a 10-mile journey, we knew we wanted wings in order to fly as efficiently as possible.

The STS paper argues that industry attempting to move forward with their UAM plans are not giving consumers enough information, considering how far along they claim to be. Companies like Uber claim that in the next five years, they will be building skyports and even offering service in major cities like Los Angeles. On their website they claim that the skyports will take up an acre or two and will handle over 1000 flights a day, but that they will not be noisy or disruptive. They do not offer any information to support these claims, if they are developing an aircraft, they should have some idea of how loud it will be. If they are going to build skyports like the renditions on their website, they need to explain how adding an airport in the middle of an already populated and developed urban area is neither disruptive nor loud. Through the research done in the technical report, I believe that these technologies have the potential to be revolutionary in a positive way, however there are also a lot of dangers and costs that come with many flying vehicles in low altitude airspace.

This paper additionally argues that society should look at the merits of each new industry as it emerges, especially regarding UAM, rather than to simply accept the coming changes. UAM is an advancement that I think should be more deliberate than it currently is, it is a very difficult endeavor and should not be compared to high altitude airspace and air traffic control. Companies that want to leverage UAM should be very forthcoming with details on how their plans will unfold, and studies should be done to determine the potential social and psychological effects of these plans. This is not a normal precaution taken when a new technology emerges, however for UAM, it should be, because it is just that different from anything we are used to.

I think doing these two projects together offered a lot of insight and perspective I would not have had doing them separately. As previously discussed, the topic for my STS research paper would not have come about without insights gained through my technical project. In addition to that, researching this paper brought knowledge regarding things like the computers for self-driving cars, which share the roads with us today. I now have a much greater understanding of how systems like that work after doing research for a similar system for our UAS. From an STS prospective, I also have newfound worries about the self-driving automobile market that I did not have previously, based on my team's experience with the same types of sensors these vehicles use.

I had never before been compelled to look at the societal factors of something I was designing quite like I did here, and I believe this was a really interesting project to have to do that. This technical project and the UAM movement that it foreshadows will have an extensive impact on society going forward, so I am glad I was fortunate enough to have this technical project as my senior capstone.