Thesis Portfolio

Corvus: Urban Air Mobility Solutions for Package Delivery

(Technical Report)

Lessons from the Boeing 737 Max 8

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

Although this capstone report is not directly related to the STS thesis, they can be loosely correlated. Both topics are studies of aerospace developments in the 21st century, with the former being a design report on autonomous drones, and the latter an in-depth look at the Boeing 737 Max 8 crashes. Further, both of these topics reflect the author's interest in modern aircraft. The capstone project was undertaken as the fourth-year aircraft design course, with the challenge supplied as a national competition by NASA. On the other hand, the STS topic was chosen because the Boeing disasters had happened just a few months before, and the fallout was still developing, with Boeing in congressional hearings and on the news every day. As an aerospace engineer, the author naturally wanted to dig deeper into the highest profile aviation disaster in years and learn from it.

The capstone project in this thesis is the report of the 2019-2020 UVA submission to the 2020 NASA Aeronautics Research Mission Directorate (ARMD) university design challenge. Every year, NASA ARMD sponsors a national design challenge for US universities to compete to solve some aerospace problem. This year, the challenge was to "design a safe, reliable autonomous system to deliver small packages to extremely short take-off and landing platforms within an urban environment"(NASA, 2019). The project was completed by a class of 13 aerospace engineering students in Professor James McDaniel's Aircraft Design class over the course of an academic year. To complete this project, engineering students divided into groups specializing in aerodynamics, performance, and propulsion, and researched state of the art technologies in each category. The class designed an autonomous drone featuring a dual-tilt-wing architecture capable of taking off vertically before transitioning to more traditional

cruise flight. Accompanying the drone was a design for a distribution center with autonomous architecture to load and recharge the drones to achieve the challenge-specified throughput. Due to the high price of individual drones and distribution center architecture, a business plan was also created that could be used to pitch the drones to companies such as Amazon and UPS.

At the time of this thesis submission, the project is almost completed. The deadline for the NASA competition is not until mid-June, so some additional changes are expected to be made. As such, the attached report reflects the most up-to-date version available. The report features detailed specifications of the drone design, along with ground infrastructure and business case, with some discussion of the design process. When completed, this project will be submitted to NASA ARMD.

The STS component of this thesis studies the recent Boeing 737 Max 8 crashes and assesses root causes and mitigations. The research question is: what went wrong that led to the Boeing 737 Max 8 crashes and groundings, and how do the disasters inform the role of the engineer in ensuring public safety? This STS research analyzes these questions, and the role of the engineer in the disasters, and in public safety in general, through the framework of Co-Production. Co-production is used in an attempt to overcome the simplifications of technical determinism and social constructivism, focusing on how society and technology develop simultaneously and interact through mutual development. In both the planes that crashed, the immediate cause was a faulty sensor triggering the MCAS system, which forced the nose of the plane downward against the will of the pilots. While the physical cause of the accidents was the faulty sensor, this research concluded that the more fundamental issue was that Boeing had not informed the pilots that the MCAS system existed, and that the FAA was not fully enforcing the

safety requirements of modern aviation due to the co-produced nature of the regulatory system. Further, the author argues that any engineering safety system can fall victim to the same issues that befell the Boeing 737 Max 8.

While the topics were not closely related, there was still value in performing both studies at the same time. The capstone project placed the author in the role of an aerospace designer, not unlike the Boeing engineers (in principle, their work is far more advanced), which provided motivation to research good engineering practices through the STS thesis. On the other hand, the STS paper provided a framework for the role of the responsible engineer, which was then used on the capstone project to design and develop a safe autonomous drone delivery service. Having a deeper knowledge of past engineering failures, as well as a better understanding of how safety risks develop helped ensure that good design practices were implemented on the capstone project.

References

NASA. (2019, September 10). University Contest. Retrieved October 1, 2019, from https://aero.larc.nasa.gov/university-contest/.