Prospectus

Fully Autonomous Drone Delivery System
(Technical Topic)

Integration and Resistance of Aerospace Automation in Society
(STS Topic)

By

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31 October 2019

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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Introduction

On December 7, 2016, Amazon Air successfully completed its first unmanned aerial vehicle (UAV) delivery (Amazon.com, Inc., n.d.). While it may seem like a trivial matter to pick up something with a drone and move it somewhere else, this was in fact a major breakthrough for the shipping industry. The versatility and maneuverability of drones far exceeds that of traditional ground vehicles, which are restricted by the placement and direction of roadways. Many believed that drone delivery was in the very near future, within the next five years at least. After all, it had just been done with a simple Amazon order in rural England. However, current drone technology must be developed further in a variety of technological areas if it is to become a safe and reliable system for commercial delivery. Using a variety of new and state of the art technologies, I will participate in the NASA Aeronautics University Design Challenge and propose my own fully autonomous unmanned aerial vehicle delivery system.

The successful deployment of a commercial drone delivery system goes beyond solving technological limitations. There is a societal network at play that has determined the fate of commercial autonomy within civilian airspace up to this point. It is important that one understands how the various network actors involved with a technology, whether indirectly or directly, affect its design and success (Callon, 1987). The case of commercial unmanned aerial vehicles, the fully autonomous variety in particular, presents a potentially radical shift in how commercial airways are to be used and interpreted. Thus, it is necessary that all actors involved in the advancement of autonomous drone delivery are scrutinized for anything that may provide a hindrance to this goal, even if the network appears to be successful.

It is imperative that the drone delivery system satisfy both the social and technical aspects of this problem. I will first outline the technical aspect of my proposed solution, providing an advanced delivery UAV design according to the standards of the NASA Aeronautics University Design Challenge (NASA, 2019). Lastly, I will utilize actor-network theory to analyze the dynamics of various parties involved in the development of a commercial autonomous drone system and how some of these parties have contributed towards an ineffective network. This paper utilizes research done by others within the AIAA community and NASA regarding UAV Aerodynamic analysis and small UAV innovations.

Technical Problem

One may typically think of drone designs as being very standardized and easy to produce by now; if it has four vertical lift rotors, then it is a "bonafide drone." While this may be true, and the quadcopter configuration is versatile, it does not mean that this standard variety of drone can be utilized for every situation in its current state. In order to meet the demands of the various parties involved in its success or failure, the delivery drone must be an extremely high-performance machine relative to modern counterparts. A high-performance machine means that this delivery drone should be able to fly safely in adverse weather, maintain the safety of its payload, and fly at very high speeds and over long distances (Noca et al., 2019).

Research into the optimization and testing of UAV aerodynamics is still relatively new and unexplored. Multirotor UAV's in particular show the most room for improvement. Most research behind the production of mass-produced multirotor UAVs is limited due to the large amount of computing power required for detailed and beneficial computational fluid dynamics (CFD) analysis on multirotor aircraft. CFD analysis is a computational method that produces airflow data on simulated object geometries. The analysis of several typical UAV models using new CFD techniques and advanced super computers has provided insight towards several new improvements for traditional quad-rotor UAV design (Diaz & Yoon, 2018). Similar research has led to potential solutions for the use of quad-rotor UAV's in strong weather and wind conditions. Unmanned Aerial Vehicles must improve their abilities to fly in adverse weather conditions, as well as their overall performance, if they are to grow into more practical roles within human society.

I propose a brand-new drone quadcopter design incorporating a number of new technologies developed from the data produced from the previously mentioned new CFD methods. High twist angle rotors, which are propellers with a sharper twist along their axis, produce more overall thrust for the UAV. Flow separators, structures built onto the UAV fuselage to control airflow, contribute to thrust as well. A new hybrid configuration, which consists of downward facing front rotors and upward facing rear rotors, will significantly increase forward thrust of the UAV. Lastly, a rotor adjustment of having the rotors angled to face slightly outward has been shown to significantly increase drone stability in high-wind conditions (Otsuka & Nagatani, 2017). In order to test the credibility of this new design, a simplified form of advanced CFD analysis will be utilized on a simulated model in order to produce quantitative data on its improved performance. If UAV's are to take on more versatile roles, such as package delivery, it is paramount that UAV's develop the performance characteristics necessary in order to complete their mission.

Science, Technology, and Society (STS) Problem

There are two types of control systems for unmanned aerial vehicles: autonomous and manual. Manual drones make up the majority of UAVs being flown today. With a human operator, one can think of the UAV in much the same way as one might think of a hobby remote controlled aircraft. On the other hand, autonomous drones carry much different connotations and implications with them. Autonomous drones are a mostly unproven technology. Despite this fact, many shipping and delivery companies, such as Amazon.com, recognize the potential for fully autonomous drones to provide an efficient, economic, and novel method of meeting customer needs (Peterson, 2019). Amazon is the driving factor in developing a successful drone delivery system. Amazon must employ the help of a multitude of other actors in order to build a strong network that is aligned with their own goals. These actors include the technology itself, the general public, the companies' customers, aerospace engineers, and governmental agencies.

Currently, the network built by amazon appears to be making solid progress towards the development of an autonomous drone delivery system. Just this year, Amazon has revealed a brand-new drone prototype for autonomous delivery, claiming that Amazon Prime Air is closer than ever before to delivering packages using unmanned drones (D'Onfro, 2019). According to Amazon, the drone is able to deliver packages that weigh less than five pounds in a safe and efficient manner. This is a major milestone in the development of a drone delivery system. Despite this success, the network built by Amazon is more vulnerable than it initially appears. This is due to the involvement of the FAA as an actor within the Amazon's network (Rupprecht, 2019).

The Federal Aviation Administration is the governing body of the United States' skies. Given authority by the U.S. Congress, the FAA is responsible for maintaining law and order for anything that goes up into the sky. Thanks to them, passenger aircraft are able to conduct their operations in a safe and orderly manner. The FAA also writes legislation that affects the engineers of said aircraft. In order for aircraft to be safe, engineers must design aircraft to meet the FAA's set of guidelines. However, the guidelines set by the FAA regarding autonomous drones make drone delivery all but impossible. What follows is a list of only some of the restrictions placed on UAVs: an operator must be able to physically see the drone at all times, the drone cannot fly at night, the drone cannot fly over groups of people, the drone must fly at certain altitudes (low), and the list goes on (FAA, 2016). One can imagine how difficult it would be to send a robotic carrier pigeon off without it violating any one of these violations within a few minutes of flight.

However, the reason these limitations are in place is in fact the *lack* of technology implementation that would allow any of these actions to be carried out safely. As mentioned earlier in my technological problem framework, research on unmanned aerial vehicle design is largely relegated to trial and error (Yoon, Diaz, Boyd Jr., Chan, & Theodore, 2017). Trial and error simply will not be able to prove whether an autonomous drone is indeed safe to use. Not only would the FAA disapprove, the general public as a whole would most certainly voice concern over potential deathtraps floating overhead of them.

In order to analyze the relationships between these untapped technologies, the FAA regulations, and a multitude of other factors in the development of a drone delivery system, I will utilize Michel Callon's actor-network theory. Actor-network theory is based on of the idea that technology and its evolution are both affected through heterogeneous networks. A heterogeneous network consists of human and non-human actors. The formation of a network begins with a network builder, which is the primary organizer within a network and the actor that determines the network's goals. All of these actors must work in unison to accomplish a common technological goal, lest the network collapse and become unsuccessful. Through this theory, I will demonstrate the importance of being able to understand all of the complex, branching factors that hinder autonomous drone development.

Conclusion

I propose a brand new, state of the art unmanned aerial vehicle design to be utilized for a commercial drone delivery system. Utilizing data gathered from the NASA Ames Research Center, I will be able to implement previously unutilized design features and configurations into my UAV. My UAV will reach all of the standards set by the NASA Aeronautics University Design Challenge. For my STS project, I will provide an analysis of the actor network at play behind the legalization and implementation of an autonomous drone delivery system, focusing on the actors that hinder the network as a whole.

The technical report will help in solving the issue of integrating a commercial autonomous airspace into society. This will be done through the testing and demonstration of my autonomous drone’s reliability and safety. Through my STS paper, I will emphasize the importance of understanding the relationships between actors of the same network and how rogue actors can affect the success a seemingly healthy network. Ultimately, I will assist in the development of a functioning, reliable, fully autonomous drone delivery system that will greatly benefit the logistic versatility of shipping companies.

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