Prospectus

Development of Package Delivery Drone for NASA's 2020 Aeronautics University Design Challenge

(Technical Report)

Exploration of Different Architectural Strategies to Facilitate Collaboration Within University of Virginia.

(STS Research Paper)

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Introduction

Since the topics of my technical research topic, designing a package delivery drone network for NASA's 2020 Aeronautics University Design Challenge, is far removed from my STS research question, exploration of architectural design impact on collaboration, they will be introduced separately.

For my technical research, our capstone class will be participating in NASA's Aeronautics University Design Challenge. For the design challenge, our capstone project will need to propose a drone delivery system network by deciding on the drone and infrastructure combined system, while adhering to safety and regulatory constraints and also presenting a profitable business case in replacing delivery trucks on last mile logistics. Through technical knowledge gained from classes and job experiences, our capstone class will present NASA with a ~40 page final report outlining a complete overview of our proposed system including potential problems identified, defining infrastructure to facilitate logistics network, and optimizing the design of the drone itself for delivery.

For STS thesis, I wanted to explore how Universities and other large institutions employ different architectural styles, methods, and objects in shared spaces to promote a collaboration to occur for the users of the space. I wanted to explore this topic because our STS group topic is on potential implementation of a contemplative collaboration space at UVA. Through looking at different examples of tools used by institutions to promote, I will attempt to examine their effectiveness, as well as the stakeholder impact in implementation of such designs. I will also attempt to find examples of identified tools and strategies employed at UVA, and document any that I am able to find.

Technical Topic

In meeting with NASA's design goals and constraints for the 2020 Aeronautics University
Design Challenge, a drone for package delivery will have to be designed with an implementation of autonomous flight control system, as well as being able to handle adverse weather conditions. The purpose of this paper is to explore potential solutions available for approach in the final design of the drone with respect to autonomous flight control system and handling of adverse weather conditions.

In Unmanned Aerial Vehicles (UAV), remote autonomous navigation control systems have existed for multiple decades. For most autonomous navigation systems, the UAV receives position and time information signals from satellites orbiting above utilizing a Global Positioning System (GPS). From the received data, the autonomous control system interprets the input and adjusts the trajectory as necessitated by the mission plan. However, to meet with the specifics of the NASA competition constraints and goals, the autonomous navigation control system will need to require additional robustness to handle multitude of possible situations, as well as be able to handle additional dimension of challenges such as its primary goal of delivering packages. One of the major unique aspect that will separate the design of this drone's autonomous control system over others is the fact that the designed drone will need to operate in urban environments. Operating in urban areas introduces a number of environment specific challenges over others. One unique challenge is that flying in proximity to urban populations, and populations in general will require the drone to fly within a tightly regulated airspace allowed. This will limit the degrees of freedom in mission planning and actual path taken to deliver packages. For this reason, the drone autonomous system will need to implement the Federal Aviation Administration's (FAA) Unmanned Aircraft System Traffic Management (UTM) framework to ensure the drone will not violate any regulations. Further challenges associated with operating an Urban Air Mobility (UAM) includes the need to implement congestion management, scheduling, interoperability, disruption management, and contingency response management system. Further challenges of this competition to the autonomous control system is that the drone will need to be able to handle the presence of adverse weather conditions. One challenge regarding adverse weather condition is that currently, most drones are not capable of flying under most adverse conditions. Therefore, the controls system will require a disruption management system to identify and avoid potentially hazardous areas of airspace.

While it would be ideal for adverse weather conditions to be completely avoided at the mission, planning level, unexpected encounters could be inevitable through uncertainty in weather forecasts, and dynamic nature of weather conditions in lengthy mission lengths. Therefore, it would be ideal for a standardized method to be developed to certify drones for certain
weather conditions. Currently, there are no standardized certification process with the FAA regarding drones operating in adverse weather conditions 2 . Since the drones designed in the competition will need to face adverse conditions, it would be useful to propose a system for testing such for drones. For certification of small sized drones for adverse conditions, standard certification procedures used for fixed wing aircrafts will not be applicable for several reasons. For traditional fixed wing aircrafts, most testing are performed within wind tunnels. However, for small sized drones, this is not an option available due to several reasons. One reason is that for small sized aircrafts like drones, the wind tunnel fails to emulate the flying condition that the drone experiences. The laminar, low turbulent, steady, flat-profile winds created by a wind tunnel are not representative of the atmospheric conditions encountered by a small sized drone 2 . One proposed solution would be to test outdoors, but this methodology leads to "poor accuracy, lack of reproducibility, dependence on day-by-day weather forecast,

unknown and non-controllable flow conditions, short test times, large distance between drone and tester." 2 For these reasons, a new methodology to test is proposed with the usage of an array of small modular fans arranged in a stack to reproduce the conditions of the conditions that a drone would face in flight. The proposed system will allow for a standardized methodology to test small sized drones to be tested for various conditions including wind and gust resistance, rain test, snow test, and hail. Through the proposed testing methodology, drone models can be tested in different expected conditions. From the results, the drone capability in different adverse conditions could influence a multitude of factors at the mission planning level depending on the predicted weather condition including path taken, amount of cargo able to be carried, estimated range, estimated time to destination, and others.

STS Thesis

Collaboration, especially in higher education environment, should be something that is desired for institutions and its students, and promoted in anyway possible. Collaboration is preferable to individual work as it prepares students for future collaborations in the workplace. Collaboration is already promoted systematically at the university level through multiple vessels. It is already promoted at the curriculum level as collaboration is already integrated into many curriculums through assignments of group projects and group worksheets. To facilitate collaborative efforts at the infrastructure level, University of Virginia has already built many number of group spaces including open conference rooms in the library, long tables at the cafe, and sofa chairs arranged to face each other at lounges.

From my personal experience, I can name a couple of collaboration spaces that I have used throughout my three years at University of Virginia. One collaborative space that I have used extensively has been the Mechanical/Aerospace lounge located on the first floor of the Mechanical/Aerospace engineering building. The lounge is only available for students who are either enrolled in Mechanical Engineering or Aerospace Engineering. The lounge has number of workstations loaded with software relevant to the major. In interviewing Allen Lang, who is also an Aerospace Engineering major and frequents the lounge describes the collaborative space as "a catalyst for meaningful collaboration, with gathering of like minded people in the same major", and also says that "conversations are easy to start with people around you since they are all in the similar classes". Regarding the furnitures and other accommodations he describes the couches in the front as "convenient resource for working on casual collaborative efforts, while the desks are often utilized for serious collaborations".

First step in exploration of different architectural impacts on collaboration is to first define collaboration in a more rigorous setting. In Kalay's *Enhancing multi-disciplinary collaboration through semantically rich representation,* collaboration is defined as "The agreement among specialists to share their abilities in a particular process, to achieve the larger objectives as a whole, as defined by a client, a community, or society at large." One thing to emphasize from the paper's provided definition is the sharing of abilities of multiple people who may specialize in different things. This is an especially important aspect of collaboration at the university level, where students of different majors, and therefore different specializations in terms of knowledge and course work, often are joined together to achieve larger objectives.

Another crucial aspect of collaboration is that it is a highly complex and challenging task. It is a multidisciplinary subject of study from a wide array of fields including sociology, psychology, politics, science, technology, and professional practices in law, medicine and engineering. The author points out that because of the widespread nature of collaboration elements present in many disciplines, specific types of collaboration can differ between disciplines. In the paper, architectural elements were explored in the context of collaboration between architecture, engineering and construction (A/E/C).

Another potential method for developing collaborative space as identified in Forlano's *Decentering the Human in the Design of Collaborative Cities* is through human-centered designs (HCD). The author identifies HCD as a methodology to create a way for a responsible, and ethical ways of engaging with emerging technologies. The author proposes decentering the human, as a way to offer designers of smart cities to approach the issues more ethically and responsibly.

In *Collaborative workplaces for innovation in service companies: barriers and enablers for supporting new ways of working*, the authors identified two questions that examined factors that may facilitate or hinder collaborative dynamics. The two questions were "1. What are the internal contingency factors (barriers and enablers) that hinder or facilitate the adoption of collaborative workplaces by companies?" and "2. How do companies and managers deal with internal contingency factors in order to undertake sustain collaborative workplace initiatives?" Applying the first question in context of collaborative spaces at the University of Virginia, there are many factors that can be identified as facilitators to adoption of collaborative space. One is that it would synergize with classes that promote collaborations through group work assignments. One factor that would hinder integration of collaborative space is dedication of space, as well as financial resources to build the infrastructure.

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