Prospectus

Hydroponic Crop Cultivation (HCC) for Food Security in Small Island Developing States
(Technical Topic)

The Human Factors Related to the Development and Incorporation of Traffic Alert and Collision Avoidance Systems (TCAS) in commercial aircraft
(STS Topic)

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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INTRODUCTION

Conventional farming works well for some environments, farmers, and specific crops. However, in many instances, it may not be the most efficient and practical method of farming. Hydroponic farming uses 95% less water and fertilizer, while producing less food waste. They give off 71% fewer carbon emissions and require 99.9% less transportation (Olesen, 2019). Babylon Microfarms, the client for my technical project, produces hydroponic micro-farms that are the size of a 15 square foot shelving unit and have a crop yield approximately equal to two thousand square feet of farmland. Additionally, Babylon's micro-farms, as well as other hydroponic farm systems, have the capability to run completely by a phone app. The app will tell you when to water your plants, when to provide them with nutrients, when to harvest them, and when to change the lighting. This makes it very simple for owners with no farming experience whatsoever to start growing vegetables. Hydroponic farming is compact, and is not designed to grow melons, squash, pumpkins, corn, and large vegetables or other large fruit trees. It is also not ideal for growing crops with deep roots, such as carrots and potatoes (Alexander, 2000).

My technical research will revolve around incorporating hydroponic farming into disaster relief for Small Island Developing States (SIDS), which are countries characterized by small size, isolation, and susceptibility to natural disasters. These nations import as much as 95% of their food and have very little crop land, making it difficult for them to feed their citizens in times of disaster relief. Crops in both conventional and hydroponic farming systems could be catastrophically ruined in the event of a strong hurricane or natural disaster striking a SIDS, and could put the inhabitants without adequate access to sufficient food supplies for a period of time. My capstone group is working with Babylon Microfarms in order to design a prototype hydroponic farms that is deployable in a SIDS. Babylon Microfarms is a local hydroponic farm producing company that creates farms for food-insecure regions and those seeking sovereignty over their own food, whether that be a small business or a home. They already have experience with to exporting their hydroponic farms to private owners, as well as providing them with the knowledge, training, and understanding in order to operate the hydroponic farms created. Babylon has apps that monitor the growth and needs of the crops, and provide the user with specific instructions on how to maintain their crops.

However, now that they are expanding to the Caribbean islands where natural disasters are more prevalent, they need to adjust their farms to make them more feasible for the outdoor environment, rather than in a local office building or restaurant in Virginia. The technical portion of my paper will discuss the need for a functioning disaster relief hydroponic farm prototype that produces the most suitable and necessary crops for a SIDS, that also utilizes the most efficient method of crop cultivation possible, so that it can supplement disaster relief efforts and increase the sustainability of a SIDS. My independent research will discuss the human factors behind the methodologies in which pilots have influenced the development and incorporation of Traffic Alert and Collision Avoidance Systems (TCAS) in military aircraft.

TECHNICAL TOPIC

Babylon Microfarms currently manufacturers hydroponic farm systems both for indoor or outdoor use. However, their focus is on the indoor farming system and this is where the majority of their expertise lies. The current hydroponic farm system deployed by Babylon and other companies is functional, but lacks the ability to withstand or adapt to natural disasters that may hit SIDS. It is essential that hydroponic farm systems in SIDS are resilient in order to provide the inhabitants with the nourishment they need in the aftermath of a hurricane, since disaster relief may take time to arrive and could come with less resources needed for the use of the people effected.

To resolve this issue, our capstone project is working towards designing a prototype for a hydroponic farm that could fit this functional need in a SIDS. Our prototype that we will design is to be storm resistant, which our group defined in three different ways. It can either be capable of floating in the event that flooding occurs, and then able to sink back down upon termination of the flood. The prototype can also be built structurally strong enough to withstand some level of hurricane or tropical storm. And lastly, we concluded that the prototype could be built to be easily foldable and transportable, so that in preparation of a violent storm the hydroponic farm could easily be moved to a disaster relief shelter to function during the storm, which is the design capability we decided to progress forwards with. The latter option is the design functionality we decided to go through with. This prototype would solve the solution of creating a hydroponic farm that is functional during and after a hurricane, because it will be fully functional indoors, in the same building in which people are taking shelter. This option is better than the first two options, because firstly, a floating micro-farm could drift off extremely far in the case of a flooding, and the micro-farm could end up in different hands than the owner when the flooding stops. Second, the structural force behind creating a micro-farm that could withstand a hurricane would require more effort, funding, and resources than the micro-farm in the first place. By building a foldable, transportable micro-farm, the farm can be moved as the owner moves, as natural disasters approach, and easily tweaked and maintained because of its maneuverability. Also, you know that if the specified disaster relief shelter can withstand the hurricane, you know your hydroponic farm will too. In addition to creating a “storm adaptive” design, our team also is conducting research on finding the best crop to grow with in the hydroponic system. We want to determine which crops are most important for the small islands, which grow the best hydroponically, which crops cannot be grown domestically through conventional farming, and which crops can remain fresh for the longest time after harvest. The last specification is not a necessity, but it would be beneficial if crops could be harvested prior to a hurricane's arrival and be consumed throughout the storm and its aftermath.

Right now, SIDS rely heavily on imports to feed their citizens. Natural disasters aside, it would be extremely beneficial for their economy to utilize hydroponic farming due to its low cost, higher yield, and more resource-efficient way of producing crops. A strong hurricane could potentially leave the inhabitants of the SIDS in question could be without access to food for periods of time, and the time that it takes for disaster relief aid to arrive is to be factored in as well. By introducing a storm resistant or storm adaptive design, our hydroponic farms would help better society for those living in on SIDS like Dominica, which is one we are working closely with at the moment. By determining the optimal specifications for power input and output, crop yield, improving physical construction, and producing the right crops, the hydroponic farms will be able to supplement disaster relief supplies for SIDS in need.

Figure1. Prototype that last year's capstone project created for the island of Dominica. This prototype was simply a hydroponic farm that could work. This year, we are expanding upon it to make it storm adaptable (Lerdeau, 2019).

STS TOPIC

Aviation technology is to me one of the most fascinating fields of artificial intelligence. In the case of the Traffic Collision and Avoidance Systems (TCAS) in particular, its development and incorporation into aviation has been affected substantially by the interactions between the human, social, and technical elements of the system. The way TCAS works is that it receives movement data from corresponding transponders in the vicinity of its aircraft, and interprets that information to determine whether or not two aircraft may be on a collision course or dangerously close to each other. Based on the information from those sensors, the TCAS will provide an alert and a recommended course of action for the pilot to perform in order to avoid the dangerous situation (Harman, 1989). The pilots face a decision every time a Resolution Advisory (RA) is issued. They can either accept the recommended course of immediate action from the TCAS, listen to recommendations from air traffic controllers (ATC) on the ground (who may or may not have agreeing or conflicting recommendations), or carry on with what they believe is the safest course of action. There are multiple examples and case studies conducted based on pilots' decision making in these situations, which I will expand upon.

The decision on whether or not to trust artificial intelligence's ability to decision make is an important sociotechnical debate. One case study in particular is of a mid-air collision between a U.S. Boeing 757 and a Russian Tupolew, in which the ATC and TCAS provided conflicting recommendations that stemmed from the pilot's hesitation to act (Weyer, 2006). There also was an observational study done on commercial airline flight crews, and whether or not pilots used their own judgment to maneuver their aircraft, or they relied on artificial intelligence assistance or encouragement (Tuttell, 1988). Additionally, there are studies performed that argue that different types of transportation should be automated or not, whether that be an aircraft, train, automobile, etc. The different laws and regulations regarding the procedures in different types of vehicles or situations needs to be addressed and clearly defined in order to prevent future issues from occurring (Inagaki, 2006). There are a variety of different stakeholders in the commercial airline industry, including pilots, passengers, air traffic controllers, engineers, the FAA administration, families, the general public, and more, whose concern revolves almost entirely around the safety of each flight.

The safe operation of aircraft saves lives and increases revenue, as patrons will continue to purchase passenger tickets as long as they believe their lives are safe. I will discuss the governing of decision making and reliance/lack thereof towards TCAS through the techno-politics and Social Construction of Technology (SCOT) framework . The SCOT theory argues that technology does not determine human action, but rather human action shapes technology. SCOT also argues that understanding how a technology is embedded in its social context needs to happen before understanding the ways to use the technology. This will guide my analysis of how the decisions and mistakes that pilots have made in the past have led to the introduction of TCAS and AI assistance in aircraft altogether. Lastly, empathy plays a huge factor in TCAS incorporation. Car accidents are much more frequent and do not always make headline news, however, plane crashes are much less common but more catastrophic. However, the odds for dying in a car crash in your lifetime is 1 in 98, while the odds for dying in air transport is 1 in 7,178, but since plane crashes generally have more deaths, the empathy factor may make people prioritize aircraft safety over car safety (Locsin, 2019).

RESEARCH QUESTION & METHODS

My research question is "How have pilots and passengers influenced the development of Traffic Alert and Collision Avoidance Systems (TCAS) in commercial aircraft?" This question is important because the human and social interactions involved with the need, development, and incorporation of TCAS is applicable to safety features in all aspects of technology (Inagaki, 2006). TCAS was researched and created because humans alone were not capable of operating aircraft without the chance for danger. However, the introduction of TCAS brought upon technological consequences, for the better and for the worse. While many problems were solved by TCAS, such as the chance of danger and the inability for pilots and ATC to detect all nearby air traffic and collision tracks, it also brought upon new issues that were unforeseen (Niu, Ma, Wang, Han, 2019). In my research, I will discuss these new issues that arose upon the introduction of TCAS, and suggest solutions. I intend to gather data in a variety of ways, to include surveys, asking the general public about how comfortable they would feel purchasing a passenger ticket to a drone aircraft vs human aircraft, as well as the extent to which pilots or AI have control over the aircraft in emergency situations or normal flight. I also will interview current airline pilots and talk with them about their opinion on TCAS and its effectiveness. In terms of secondary resources, I intend to research and analyze case studies performed on the socio-technical interactions of the TCAS and pilots, as well as the effects of mid-air collisions on consumer behavior.

In terms of the technical project, we are already in the process of creating a survey that will best help us identify our clients in Caribbean SIDS. There also are plenty of media reports that address that catastrophic situations that SIDS find themselves in post-hurricane, and it is evident that they need a method of food security in their domestic land. Through working with Babylon Microfarms, I will also be able to learn how to optimize crop yield in hydroponic farming, and which combinations of farming methods pair best with different crops. This information will be very beneficial in determining the "golden" crops to be produced in SIDS, which is one of our current tasks.

The current problem with farming in the Caribbean is that SIDS do not have food security. They import the majority of their crops since they do not have the capability to grow domestically, and the size of the island means that the whole island is ruined in the event of a hurricane. Therefore, they do not have the capability to sustain themselves and rely heavily on disaster relief. By incorporating hydroponic farming into their agricultural practices they can grow essential crops themselves, and by creating a storm resistant or adaptive designed hydroponic farm, people are able to feed themselves in the event of a natural disaster and sustain their agriculture while recovering from natural disasters.

In regards to my individual research on the Traffic Alert and Collision Avoidance Systems, I will analyze the social and technological impacts that the introduction of TCAS has created, as well as the ways in which the stakeholders in aviation have played a role as well. This will help me gain a greater knowledge on how society and technology interact with one another, as well as create connections with future technological impacts both in the aviation world and not.

As for my timeline, I intend to get started on my sociotechnical synthesis as soon as I possibly can next semester. I am good at prioritizing my work, and I realize that with the technical report for my capstone being a group project, it may be difficult for everyone to be on the same page at the start of the semester. I will aim to finish my own personal parts of my senior thesis first, being the sociotechnical synthesis and my STS research paper. I have to plan a "Dining In" celebration for the ROTC unit in late March which will take up a decent amount of time, and I also plan on doing something pretty fun for spring break. Therefore, it will be important for me to get a head start on things in January and February right when I get back to school. Getting a head start on my STS research paper and sociotechnical synthesis will help make me be available to help out on the technical report whenever my capstone group plans to start working diligently on it, which I expect may not begin until March just based on how things are going so far this semester.

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