Thesis Portfolio

High Resolution Satellite Imaging of Nitrogen Dioxide from Low Earth Orbit

(Technical Report)

Exploring the Viability of Unmanned Aerial Vehicles in the Private Sector

(STS Research Paper)

An Undergraduate Thesis

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Sociotechnical Synthesis

While the technological advancements of the past two centuries have allowed humans to accomplish feats that were never thought possible, it has become increasingly apparent that many of these developments were shortsighted. With an improved quality of life and unprecedented growth of the human population, the industrial practices established during this era have also brought about increased levels of pollution, a rapid decay of biodiversity, and an immense decline in overall environmental health. As such, the subjects of my technical report and STS research each have a central focus on mitigating the environmental effects created by these practices.

For my capstone project, my team and I have developed a nanosatellite, known as a CubeSat, that can detect the concentrations of various pollutants in the upper atmosphere using spectrographic instruments. With this data, we aim to better understand the anthropogenic effects of emission-based pollutants and direct policy makers on how to alleviate their effects in the areas that are most affected. Similarly, the objective of my STS research is to determine the economic viability of Unmanned Aerial Vehicles (UAVs) in the agricultural and delivery industries and demonstrate how this technology can vastly reduce the quantity of pollution generated by each industry. While the environmental benefits associated with implementing this technology are quite compelling, there are several economic, cultural, and legal obstacles that have stagnated their operation. My technical topic and STS research each aim to mitigate the anthropogenic effects of modern human practices. However, whereas my technical topic is focused on evaluating and refining our understanding of emission-based pollution, my STS research is focused on exploring an alternative technology that can vastly reduce pollution across two major industries.

In recent years, climate change has become one of the most widely discussed topics in the political and economic domains. Climate change, formerly referred to as global warming, refers to a rapidly changing climate as a result of increasingly high levels of greenhouse gases in the atmosphere. Many climate scientists point to an ever-increasing dependence on fossil fuels as the major culprit of this phenomenon. As such, my technical research focuses on detecting levels of Nitrogen Dioxide (NO_2) in the atmosphere using a 3U CubeSat. We have chosen Nitrogen Dioxide as our target chemical because it is a well-known greenhouse gas with documented spectral properties. As such, by measuring the atmospheric concentration of this gas we can estimate the concentration of several other pollutants that are more difficult to measure across large areas. As each of these pollutants have a unique spectral signature, the satellite is fitted with a custom-made spectrograph that is capable of measuring NO_2 columns with a spatial resolution of at least l km^2. The satellite, which is scheduled to launch from the ISS in the spring of 2021, will operate in Low Earth Orbit and detect the concentration of NO_2 over seven key cities. With this data we can improve the existing models of NO_2 pollution while also attaining a better understanding of the atmospheric effects of emission-producing technologies. As there are several alternatives to fossil fuels, this data may be used to guide legislation to establish better regulations or incentivize large manufacturing firms to shift toward clean energy.

Though my STS research focuses specifically on the viability of UAVs in the agricultural and delivery industries, this topic draws several parallels with my capstone project. According to the EPA, the two industries in question contribute roughly one-fifth of the total U.S. emissions in addition to other forms of pollution. As UAVs are typically emission-free and have the technical capacity to replace several existing technologies used within these industries, their implementation could drastically reduce each industry’s carbon footprint. Additionally, this

research shows that there are several financial benefits associated with substituting current technologies with UAVs. The major existing technologies explored in this research are crop dusting planes in the agricultural sphere and delivery trucks in an urban delivery setting. Through a cost-benefit analysis it becomes very clear that UAVs can provide a cheaper alternative to these technologies while decreasing the human input required for their operation. Furthermore, when comparing the energy input of UAVs with that of formative technologies, it is undeniable that they cause significantly less harm to the environment. Nevertheless, their adoption into these sectors has been very gradual due to several economic, cultural, and legal obstacles. The economic barriers stem from the fact that there is a large initial cost of replacing existing technology with UAVs. While this issue is not as prevalent in the delivery industry, which is dominated by large corporations, it does affect their adoption into the agriculture sphere which is mostly comprised of small, family owned farms with less access to capital. The cultural barriers that inhibit their adoption typically result from the military origins of UAV technology which typically saturates the public discourse about their use. The most prevalent obstacle, however, pertains to the legal restrictions that greatly limit the ability of UAVs to compete with existing technology. Since several FAA regulations inhibit commercial UAVs from exercising their full technical capacity, they cannot adequately compete with existing technology.

These projects are both extremely valuable as they each explore ways to improve the human impact on the environment. By working on both of these projects simultaneously, it has become clear that there is a lot that can be done to decrease our impact on the environment. These projects have demonstrated that shifting toward sustainable practices is not always an economic burden and that ecological measures can actually stimulate the economy and increase profits when implemented correctly. While my technical topic is focused on directing regulatory

policies across key manufacturing regions, my STS research is focused on determining how regulatory policies have restricted the ability of UAVs to reduce the environmental effects of agriculture and delivery. However, together these projects show that while there is definitely a problem, we already have many potential solutions that are just waiting to be applied. This research shows that there are several current technologies that if applied properly can provide subsequent generations with a healthier and more vibrant planet.