Thesis Project Portfolio

High Resolution Satellite Imaging of Nitrogen Dioxide from Low Earth Orbit

(Technical Report)

Bridging the Gap: Using Actor Network Theory to Map Sociotechnical Forces in Air Pollution-Affected Communities

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Science

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In Fulfillment of the Requirements for the Degree

Bachelor of Science, School of Engineering

William Schaefermeier

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Department of Aerospace Engineering

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Sociotechnical Synthesis

The Spacecraft Design capstone class is a well-established program in the aerospace engineering major, constituting more than 15 years, a dozen projects, and multiple satellites in orbit. When I joined one of the class's ongoing projects, the curriculum and schedule were well established. Throughout my participation, the actual technical objectives of the project were clearly present: design and launch a cubesat - a small satellite comprised of modular components capable of detecting nitrogen dioxide over heavily polluted cities. However, nowhere throughout the project was the *reason* discussed: what is the purpose for collecting this data? What will it be used for? This absence of a deeper purpose formed the basis of my STS research - I wanted to explore the apparent gap between the wellspring of available data on the dire consequences of air pollution and the lack of widespread means to clearly disseminate this data to those who could benefit from it. While my argument and discoveries evolved throughout the year, the backbone of my STS thesis remained: knowledge on its own is not enough; it must be contextualized by its social environment to become a force for change.

For the technical portion of my thesis, I joined a three-year satellite project in its second year of design. We were tasked with continuing the design of a nitrogen dioxide-sensing 'cubesat', a small satellite made up of uniform 10cm by 10cm modules. The previous year of research had yielded a preliminary but complete conceptual design; we were tasked with carrying it through the design process from preliminary design review to critical design review, at which point our design becomes finalized and ready for assembly and testing. I worked in the subgroup handling data and communications, and have spent the last 9 months researching prebuilt processors and radio modules, operating systems and computer languages commonly used on cubesats, and data

communication protocols over wired connection and radio waves. This research culminated in selecting a viable central processor, S-band transmitter, and UHF transceiver, as well as mapping the data architecture for the entire system and developing software algorithms for each of the satellite's primary objectives.

For my STS research, I developed a method of analyzing communities through the lens of Actor Network Theory to determine their susceptibility to air pollution reform. Initially, I explored the disjunction between the trove of data correlating air pollution to all sorts negative health, economic, and social effects and the apparent lack of much air pollution reform on the community level; in other words, if we know exactly what the problem is, why is it so difficult to fix it? In my research I came across a multitude of studies examining the negative effects of air pollution in different communities, and was struck by the complexity of sociotechnical forces present within each study. A rural province in China suffers from high lung cancer rates and dire air pollution because of the lack of variance in the economy and the heavy reliance on bituminous coal as a heat and power source, while an air pollution-monitoring app is able to gain traction in California due to the community connections used to promote it and a large, young, wealthy demographic to which it appeals. My research morphed into creating a tool to analyze these sociotechnical forces; I created a method to use Actor Network Theory to map sociotechnical forces and their interplay, and analyze each scenario for its susceptibility to climate change reform.

While the general topics of my technical and STS projects only superficially overlap, my research and work on each often informed the other in small but impactful ways. Discovering ways of mapping relationships and cultural forces for my STS research gave me insights on how to organize the software systems of the cubesat, and trolling the user manuals of different satellite

hardware systems helped me develop methods of scanning technical papers (including other STS theses) to find the exact information needed. My research has led me to see the critical importance of connecting scientific research with actual real-world situations, and in turn understanding the social and cultural pressures that guide engineering development. Most importantly, I've learned to observe critically, use any and all available resources, and make sense of the complex webs of relationships present in engineering society.