Thesis Portfolio

HIGH RESOLUTION SATELLITE IMAGING OF NITROGEN DIOXIDE FROM LOW EARTH ORBIT

(Technical Report)

Don't Tread on My Planet

(STS Research Paper)

An Undergraduate Thesis

Presented to the Faculty of the School of Engineering and Applied Sciences
University of Virginia • Charlottesville, Virginia

In Fulfillment of the Requirements for the Degree
Bachelor of Science in Mechanical Engineering, Aerospace Engineering

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May 01, 2020

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SocioTechnical Synthesis

The technical thesis focuses on the development of a CubeSat to study nitrogen dioxide (NO_2) levels from space. NO_2 is an anthropogenic pollutant that is linked to impaired lung function and lung irritation. NO_2 also acts as a general pollutant indicator to study both mobile and stationary pollution sources. Concentrations of NO_2 vary widely throughout the atmosphere, so the mapping of the pollutant is best done from space. Studying NO_2 from space will help create a high-resolution model of the spatial gradients of NO_2 levels throughout the atmosphere. This will help establish trends for pollution concentrations and help better understand the behavior of the pollutant. To study NO_2 from space, the team worked to design a novel CubeSat with a custom NO_2-focused spectrograph to allow for mapping of the Earth's atmosphere. The spacecraft will be launched into low-earth orbit, from which it will conduct numerous passes over target areas to collect data. This data will help to improve our understanding of pollution and emissions, primarily in urban environment.

While earth-orbiting satellites offer great opportunities for earth science and research, deep space exploration is also at the forefront of space innovation. The STS thesis focuses on the planetary protection concerns of deep space exploration. As humanity expands its reach into the cosmos, we carry a responsibility to both protect celestial bodies from contamination and to safeguard the Earth from potential space-borne hazards. Groups such as NASA and SpaceX are currently developing the spaceflight systems needed to carry humans into deep-space and put humans on the surface of Mars. In this process, it is imperative that the Earth is protected from potential bio-hazards from outer space. While the likelihood of space-borne pathogens is exceedingly low, the potential consequences could threaten all life on Earth. In addition, it is important to protect other celestial bodies from contamination from life on Earth, both to

maintain our ability to properly study the astrobiology of these bodies and to respect the ethical considerations of altering foreign astronomical bodies.

To unpack these problems, the theory of responsible innovation will be used to gain insight into the future of humanity's exploration into the final frontier. Additionally, actor network theory will be used to analyze how the various actors within space exploration interact with each other and how the philosophical and ethical differences between these actors could come into conflict. To study these problems, two main methods will be used. First, the existing planetary protection policies for a manned mission to Mars will be analyzed to establish the existing approach to handling planetary protection concerns. Second, a case study involving SpaceX's launch of a Tesla Roadster will be analyzed to evaluate the planetary protection concerns surrounding the mission.

The research found that while planetary protection is an issue that is taken very seriously by space agencies and regulatory bodies, the complexity of a Mars mission will force more liberal policies to be adopted for human deep-space exploration. Additionally, the study of SpaceX's Tesla Roadster launch reveals that the rise of the private space industry threatens to conflict with established planetary protection policy and norms. This research highlights a contrast between ambition and responsibility, as the space industry attempts to make another big leap forward into the cosmos.

For the first time in Earth's history, life is no longer bound to a single planet. Technological advancements by human beings has made it possible for humanity, and therefore life, to spread to other celestial bodies. The gravity of this is difficult to comprehend, but future historians will likely point to this era as a major turning point in the role humanity plays in the cosmos. Consequently, humanity will soon need to decide what that proper cosmic role is.