Sociotechnical Synthesis
(Executive Summary)

Wildfire Prevention as a Sociotechnical Challenge: From Detection Systems to Regulatory Failures

"When we try to pick out anything by itself, we find it hitched to everything else in the universe."
— John Muir

California's wildfires have grown more deadly and destructive each year, often ignited by outdated infrastructure and worsened by a lack of preparedness. As an engineering student who witnessed wildfires destroy neighborhoods in the city I grew up in, I wanted to not only help design solutions to mitigate these fires, but also learn why they keep happening in the first place. My thesis reflects this dual focus. For my technical project, I helped design a low cost, real time detection system that attaches to electrical poles in forests that uses infrared flame and temperature sensors to detect and notify communities to potential wildfires before they spread. At the same time, my STS research used Actor Network Theory (ANT) to analyze the 2018 Camp Fire, the deadliest wildfire in California's history, and revealed how PG&E's equipment failures caused these fires along with regulatory neglect, climate extremes, and prioritizing profit. What links these two projects is the acknowledgement of how systems function, or fail, in the real word. Engineering projects only succeed when they account for the systems they operate within. My goal was to explore how detailed technical design alongside a strong understanding of the broader social and environmental context can lead to safer infrastructure.

The technical project was a fire detection system that focuses on one of the most common wildfire ignition sources: electrical transmission equipment. Our device a pyroelectric infrared

flame detector and a digital temperature sensor to detect heat and flames near sensors. This device is placed on electrical poles with the sensors facing down the electrical lines to detect if a fire is started. When one of theses sensors detects a fire, the system send a wireless alert using LoRa communication. Each device relays alerts from node to node, creating a chain that sends the alert to a central control station at the end of an electrical pole system. This decentralized communication is especially valuable in remote, rural areas where there is no internet connection. We built a web interface that maps each device's status and lets the user at the control station view alerts in real time. The system was designed with low power requirements and a weatherproof container, to make sure it can function properly in remote locations. Our design solves the issues of delayed satellite imaging and centralized alert systems that current fire detection systems have.

In my STS research, I examined the 2018 Camp Fire through the lens of Actor Network Theory. ANT helped me argue that the Camp Fire was not caused by a single failure, but by the interactions of multiple human and non-human actors over time, which revealed a complex network of responsibility. PG&E's century old equipment, its decision to dealy infrastructure upgrades in favor of profit, CPUC's inability to enforce meaningful safety reforms, and intensifying drought conditions all greatly contributed the collapse of this system. No single actors caused this fire alone, but all played an active role in shaping the conditions that allowed it to happen. This framework revealed that the failure wasn't only technical; it was also structural, institutional, and systemic. Even actions like vegetation removal or public safety power shutoffs, which seemed like great steps in the moment, served as more of a short term fix than long term solution.

Together, these two projects reshaped how I want to approach engineering. Designing technology is important, but understand how it acts in its environment is paramount. My STS research helped me see that even state of the art technical solutions will fail if they lack the needed support, structure, or accountability. For example, a fire detection network like the one we designed has the potential to provide valuable data, but if it has to work with similar regulatory and corporate structures from the Camp Fire network, it will not succeed.

These experiences have shaped my understanding of what it means to be a responsible engineer; someone who not only focuses on technical precision, but also remains aware of the systems, communities, and consequences their work impacts.