Personal Statement, Relevant Background, and Future Goals

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I have always been excited to learn and explore new things. My thirst for knowledge led me to complete an NSF REU project, spend two summers researching avionics at NASA JPL, and dedicate myself towards a student-built satellite that will launch next year (and help the Air Force improve its space situational awareness capabilities). These experiences pushed me to enroll in the PhD program at the University of Michigan, where I hope to continue to learn and make an impact on society.

FIRST Robotics. I am the type of person who becomes really passionate about a project and devotes himself fully to it. In high school, that project was FIRST Robotics. I became head programmer for our robot, teaching myself C as I went. The engineering mentor working with our team gave me the opportunity to experiment and try new ideas. I was able to play with vision software and make the robot follow a green light around the room. He even supported me when I tried to determine the robot's position based on the readings from an accelerometer alone. I found out the hard way that error in the second derivative adds up quickly, but I gained a new understanding from having attempted it. FIRST Robotics provided me with the opportunity to learn and experience, and led me to decide that engineering was the field for me.

NSF REU. Throughout my undergraduate experience, I focused on finding new and interesting projects to work on and learn about. One summer I worked at Michigan Tech as an NSF Research Experience for Undergraduates student focused on Hybrid-Electric Vehicles. The **broader impact** of this project was to use the data we collected in order to train autoworkers across the country in this new field. I was excited to have the opportunity to expand my knowledge outside of the range of my previous experiences.

Many hybrid-electric vehicles use continuously variable transmissions in order to maximize efficiency. My work focused on collecting data from a test vehicle and using it to define an equation that modeled the function of its continuously variable transmission. The research consisted of a cyclical process: gather experimental data from the vehicle, compare that data to the outputs of equations we used to model the forces at work, find problems, and then design new experiments for the vehicle. For me, the experience led to a much better understanding of the benefits of interdisciplinary work, and the difficulties of matching models to the real world.

Aerospace Enterprise. While robotics was my driving force in high school, my passion throughout college was satellites. I joined the Aerospace Enterprise at Michigan Tech, a group of students devoted to a single goal: "Until we reach space." We participated in the University Nanosatellite Program sponsored by the Air Force Research Laboratory. As part of the project, we were given two years and $100,000 to create a satellite.

Our mission was to enable Space Situational Awareness capabilities for the AFRL. The satellite will be spectrally characterized while still on the ground, and then spectroscopy will be used to determine its configuration and attitude while in orbit. The **intellectual merit** of the project lies in its ability to determine what a satellite is doing through optical means alone. The Air Force intends to expand this program to all domestic satellites, increasing their ability to debug problems on orbit. The capability to determine this information is new, however, and algorithms to do so are not currently very accurate.

To this end, we developed our satellite to be able to perform maneuvers and orientation changes with a high level of attitude knowledge. This data will allow the Air Force to calibrate their algorithms based on us. One of my responsibilities as a team leader was to ensure that these goals could be fulfilled. This included everything from making sure that commands existed to direct the satellite to perform tasks, to ensuring that the generated data was compressed enough to be downloaded within our radio talk-time windows.

The **broader impact** of the research lay not in the results, but the method. The entire project was led and staffed by undergraduates with a single faculty mentor. Aerospace engineering, and satellite technology in general, is not part of the curriculum at Michigan Tech. Therefore, learning and teaching were the number one priorities for all team leaders. I devoted much of my time to teaching the students on my team. As I grew more experienced, I realized that the problem was not just a lack of knowledge, but a lack of desire. Too many students were content to live in a bubble. They worked on computers or structures or control algorithms, and had no concern of how the system functioned as a whole. I made it a goal of mine to correct this, and taught the students I worked with to always keep the bigger picture in mind.

The scale of the project and the number of students involved had originally intimidated me. I had worried that I would not be able to have much of an impact on the project. There is always work for the willing though, and by the time I graduated, I had designed much of the satellite's computer hardware, software, command system, and concept of operations, and had presented these designs to the AFRL on numerous occasions. We won the national competition in 2011 and the team is finishing preparations for a launch into space in 2015.

NASA Jet Propulsion Laboratory. Due in part to my efforts in the Aerospace Enterprise, I was given the opportunity to work at NASA's Jet Propulsion Laboratory for two separate summers. The first summer, I worked with the Electric Propulsion group. They were testing a new thruster design, and needed a computer controller for the system. I experienced the simultaneous joy and terror of creating an entire project from scratch, taking the project from determination of requirements all the way to fabrication and testing. An undergraduate's time is mostly spent working on heavily specified projects and homework with conclusive answers. The opportunity to freely explore a design space and come up with my own solution to a problem was invaluable to me. What started as a set of dimensions and a vague mandate to "make it low power" became a populated board with the ability to monitor various sensors, control thruster voltages, and store data until it was requested by the operators.

The second summer I was at JPL, I worked with the Advanced Computer Technology group testing a new ASIC design. This involved not only being able to prove a specific chip was functional, but also creating a framework that could be used to test future revisions. The experience was very different from my first summer at JPL. This time I was working with a group of experts in my own field. I could discuss in-depth architecture design questions with them and benefit from their experience.

I consider spreading research ideas to be very important. Each summer I was at JPL, I was lucky to be able to present at their Cubesat Symposium, which gave me the opportunity to disseminate Aerospace Enterprise's research goals and experiences to professionals in the aerospace field.

SensEye. Within computer engineering, my love has always been for embedded systems, where hardware and software are each designed with the other in mind. I am inspired by the idea of smart devices and new platforms which can enable people as never before. Since beginning a PhD program at the University of Michigan, I have been working on a project called SensEye.

The SensEye project explores the question, "What could a computer do if it was able to know where you are looking?" At the core of the project is low-power gaze detection enabled by a new generation of imagers. Two cameras are attached to a pair of glasses, with one camera focusing on the world at large while the other tracks the user's eyes. The challenge is to collect that data at a high enough frame rate for useful gaze tracking while still minimizing power use. With on-board compression minimizing data rates, the system will be capable of wirelessly transmitting gaze information to devices like your smartphone. The **intellectual merit** is the creation of a new method for interacting with computers.

Broader Impact. I am indebted to the people who inspired me, and I want to give back to others in turn. When I was invited back to my high school to speak about my research work to students, I jumped at the opportunity to be their inspiration. I found the experience to be very rewarding. Effectively explaining research so that even a non-technical audience can understand it and be interested is an important skill to have.

Whenever the ECE Department at Michigan Tech gave tours for prospective students, I volunteered to help introduce them to the department. I enjoyed being able to show students what I loved about engineering and get them as excited about it as I am. For my volunteer activities as well as my research in the Aerospace Enterprise, I was proud to have been named ECE Departmental Scholar for 2012.

Future Goals. I entered graduate school because I want to become a professor. Faculty members have a profound influence on developing students, and I have seen firsthand the impact that a mentor can have on young minds. I am currently a Graduate Student Instructor for a junior-level computer engineering course at the University of Michigan. I teach two discussion sessions a week for approximately thirty students each and hold office hours. The experience of dedicated teaching has been a wonderful one for me, and has served to confirm my desires for teaching. A NSF Fellowship will provide the foundations of a research career and help accomplish my goal.

Conclusion. My experiences in research have prepared me to be a successful graduate student. I have been inspired by the opportunities I have been given, and in turn desire to inspire others through impactful research and outreach. My passion for learning and exploration makes me an ideal NSF Fellow.