Development of Testing Station for Prototype Rover Thermal Subsystem

Kaitlin Burlingame

Summer 2010 MUST Intern

NASA Johnson Space Center

ER4: Robotics Systems Technology Branch

Mentor: Thomas Waligora

I. INTRODUCTION AND ABSTRACT

In order to successfully and efficiently explore the moon or other planets, a vehicle must be built to assist astronauts as they travel across the surface. One concept created to meet this need is NASA's Space Exploration Vehicle (SEV). The SEV, a small pressurized cabin integrated onto a 12-wheeled chassis, can support two astronauts up to 14 days. Engineers are currently developing the second generation of the SEV, with the goal of being faster, more robust, and able to carry a heavier payload. In order to function properly, the rover must dissipate heat produced during operation and maintain an appropriate temperature profile inside the rover. If these activities do not occur, components of the rover will start to break down, eventually leading to the failure of the rover. On the rover, these requirements are the responsibility of the thermal subsystem.

My project for the summer was to design and build a testing station to facilitate the design and testing of the new thermal subsystem. As the rover develops, initial low fidelity parts can be interchanged for the high fidelity parts used on the rover. Based on a schematic of the proposed thermal system, I sized and selected parts for each of the components in the thermal subsystem. For the components in the system that produced heat but had not yet been finalized or fabricated, I used power resistors to model their load patterns. I also selected all of the fittings to put the system together and a mounting platform to support the testing station. Finally, I implemented sensors at various points in the system to measure the temperature, pressure, and flow rate, and a data acquisition system to collect this information. In the future, the information from these sensors will be used to study the behavior of the subsystem under different conditions and select the best part for the rover.

II. GOALS AND PURPOSE OF THE PROJECT

Engineers working on the SEV are producing the next iteration for a rover to transport people around the surface of the moon or other planets. The SEV can support astronauts on long duration missions (up to 14 days), and different tools can be attached to the rover to facilitate exploration. As shown in Figure 1, the chassis of the vehicle has six wheel modules. Each wheel module has independent steering, allowing the rover to drive in any direction, and independent suspension, allowing the vehicle to drive over rocky terrain and up steep inclines.


Figure 1. Space Exploration Vehicle. Photo Credit: www.nasa.gov

Throughout its operation, the rover has to survive in a wide range of temperatures. In addition, most components in the rover are partially inefficient and therefore produce heat when they are operated. Each part of the rover has a specified temperature range where it can operate. Outside this temperature range, its performance will start to deteriorate until failure. The thermal system is responsible for controlling the temperature inside the rover so that the integrity of the parts is maintained.

There are many steps leading up to the implementation of a design as a prototype. Two of these steps are selecting the components to be used and completing analysis on their performance. For my project, I created a testing station on which to test various components and configurations of the thermal subsystem in order to produce the best rover. Using a testing station like this reduces the risk of components failing once the rover is built and makes it easier to pinpoint the best component. In addition, having a testing station makes it possible to model different components or configurations in case the design changes in future iterations.

The overall goals for my project were to make a testing station which would support thermal system design and analysis for all phases of the SEV design process as well as for the design of other robots. My approach to the project was to use a layout that allowed easy access to the parts and to select fittings that were easily interchangeable, allowing parts to be switched out as higher fidelity parts are chosen.

Knowing the performance of components, both individually and in conjunction with each other, is critical to selecting the best component. Based on this need, another part of my project was to select sensors that would collect data on the flow rate, temperature, and pressure at different points in the system. The position of these sensors in the system could be changed to measure at different points in the system or to just measure across a single component. Data from single components can be used later to predict the effect on the system if a design change is made.

In addition to selecting the sensors, a method of displaying and storing the data was necessary. I selected a data acquisition system to collect, display, and store data from the sensors using a program called LabView. This program can be also used to automate the electrical components in the thermal subsystem to simulate different drive cycles of the rover. Since this system takes time to implement, I also chose a display system that is quicker to set-up and displays data directly from the sensor. Although I only played a small role in the process, the completion of a testing station for the thermal system was a necessary step along the path that will lead to the next Space Exploration Vehicle and our exploration of the moon and other planets.

II. Impact of the MUST Internship on My Career Goals

My internship this summer has significantly impacted my personal and professional development, leaving me better prepared to continue my studies and move forward to the next steps in my life. I am currently studying mechanical engineering and I plan to put my education to use in mechanical design or systems engineering in the space or medical industry.

As I worked alongside engineers in my group, I was able to see how the engineering concepts that I have been studying in school are applied to create NASA robotics. In addition, since the group was working on multiple projects at the same time, I was able to see robots being designed, built, and operated. In most cases, the concepts I study in class never leave the textbook or chalkboard. For example, though I have taken fluid mechanics and heat transfer, I had never actually seen a pump or heat exchanger. Through my internship this summer, I was able to use the concepts I learned in class to size and operate these components. As I discovered how the components operated and work to integrate them into a system, my understanding of the engineering behind them and their applications stretched far beyond what I could have ever attained in class. Feedback from my mentor and the other engineers in my group also gave me knew insight into the best way to perform the tasks I was asked to do.

Interning with NASA also made it possible to see the kind of things that professional engineers do on a day to day basis. I was able to inquire about the paths that many of my coworkers took to get to their positions and ask questions related to the opportunities in my future. As I go into my final year at school and face decisions about the next step in my life, I feel much more informed about the options I have based on experiences and conversations I had during my internship.

In addition to all that I learned from my internship, I had the opportunity as a NASA intern to mentor a group of high school students participating in the Texas Aerospace Scholars program. As the students planned a week long mission to Mars, I worked with them as an advisor. This experience allowed me to learn about mentoring in a technical context, which is something that I will strive to implement next year with younger students and in the future. In addition, seeing the fire these students had for science and engineering reignited the interests that caused me to choose engineering.

Although I was only a NASA intern for ten weeks, I feel that I have been able to make a significant contribution to the group and center where I worked, as well as to the agency as a whole. Concurrently, I believe that the skills, insight, and experiences I acquired while participating in the internship have made a significant impact on my preparation for my future career and my outlook towards engineering. Throughout the internship, there were many moments where I found myself thinking about how grateful I was for this opportunity, and I do not think that gratitude will diminish any time in the near future.