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Electrical Engineering/Junior

NASA Johnson Space Center

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Purpose: Inform reader of cooperative education experience at the NASA Johnson Space Center.

Objective: Obtain practical working experience in the electrical engineering field.

History:

The National Aeronautics and Space Administration (NASA) was founded in 1958 by President Dwight Eisenhower. NASA was created largely because of concern over the Soviet Union's foundation of a space program. Since then, NASA has collaboratively worked with international partners and accomplished many scientific and technological achievements. Many of those achievements have been adapted for use in the private sector.

Figure 1: Aerial view of the NASA Johnson Space Center.

There are 11 NASA Space Centers across the United States which employ nearly 19,000 workers. The Lyndon B. Johnson Space Center (JSC) has the largest federal workforce of all the NASA Space Centers. JSC was established in 1961 and was formerly known as the Manned Spacecraft Center. Today JSC consists of over 100 buildings covering over 1600 acres of land. The land upon which JSC was built was donated by Rice University. JSC's role within the agency is primarily to provide spaceflight training for astronauts, flight control, and research innovative technologies.

The Energy Systems Division is a division of the Engineering Directorate at JSC. Within the Energy Systems Division, the Power Systems Branch (EP5) provides design, development, testing, evaluation, integration, and operational support of components and systems involving energy storage. The EP5 branch is also responsible for the transmission, distribution, and conditioning of electrical power.

Work Assignments:

My primary task on my first tour at JSC was to assist my mentor, Sheikh Ahsan, with a research study he is conducting on aluminum wire. While assisting my mentor with the aluminum wire study, I've also had an opportunity to complete work for other projects including the In-Situ Resource Utilization (ISRU) Project and an Electrolysis Project for Innovation Day at JSC.

Aluminum Wire Study:

My first task given by my mentor was to familiarize myself with aluminum wiring. I was given many reading materials to gain a better understanding of the use of aluminum wiring and its respective advantages/disadvantages versus copper wiring. NASA is interested in this because of its benefits in the aerospace industry. Even after factoring in the larger gauge of wire required for matching aluminum wire to its copper equivalent, a wiring weight reduction is possible. Aluminum wire is currently being used in the commercial aircraft industry. In terms of space however, aluminum wire usage is limited to few European Space and Defense programs. For potential future utilization of aluminum wiring at NASA, a technology maturation program is needed.

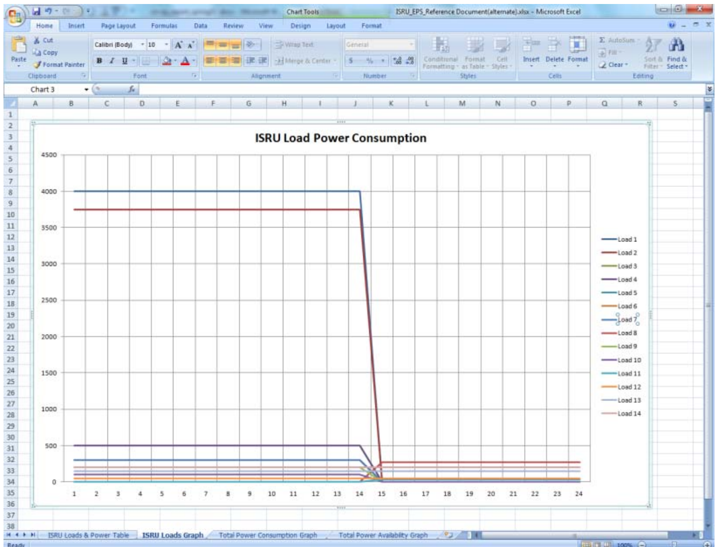

Figure 2: ISRU Load Power Consumption Management Graph.

The data collected from this study would serve as a reference resource for use at NASA. I attended a Test Readiness Review (TRR) for the testing completed at the Energy Systems Test Area (ESTA). I also had an opportunity to witness the some of the tests completed at ESTA. During my mentor's absence, I presented the work completed so far with the Aluminum Wire Study to Harry Partridge (Director of the Game Changing Technology Division at NASA Headquarters) and also to Steve Altemus (Director of the Engineering Directorate at JSC).

ISRU Project:

The goal of the ISRU Project is to research and develop technology to extract available resources on the moon and Mars. The project requires a collaborative effort from various NASA Space Agencies to integrate different loads onto a prototype lander vehicle. Each one of the loads functions properly and performs a vital functionality with respect to the extraction process. Currently there is a planned process of transitioning from each load operating separately on 120VAC power to integrating the loads to operate on a closed loop

Figure 3: Example of a SSPC Card manufactured by DDC.

28VDC power system. I produced top-level system diagrams for the various loads of the project using Microsoft Visio. I also assisted with the development of the electrical power system and power distribution unit design for the project. I learned about designing an electrical power system and many of the considerations which need to take place while doing so. The process of selecting parts, obtaining quotes, and speaking to numerous vendors proved to be a valuable experience. During the process of selecting parts, I assisted my mentor in organizing a demonstration of a multi-channel solid state power controller (SSPC) card at ESTA. Using Microsoft Excel, I also created a Power Management Spread Sheet to maintain information about the various loads as the design would have to accommodate to modifications that were taking place.

Electrolysis Innovation Day Project:

Innovation Day at JSC is an event held to demonstrate innovation and collaboration within the center. The Propulsion and Fluid Systems Branch planned on demonstrating an Electrolysis System for the event.

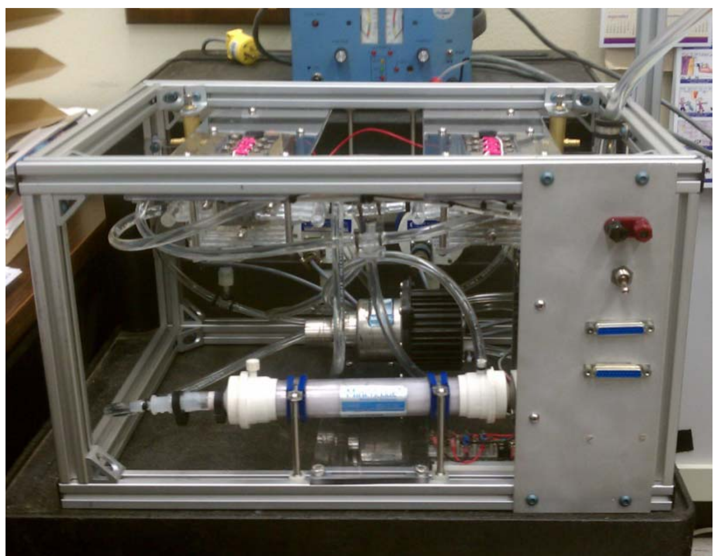

Figure 4: Innovation Day Electrolysis System.

During the buildup of the system, my mentor provided consultation for the electrical system design. Using Microsoft Visio, I produced a high-level electrical system schematic of the design and attended meetings for the build-up of the project. The technicians at ESTA were responsible for the buildup of the actual Electrolysis System. Due to issues with having a 120VAC outlet available, I assisted in the investigation of alternative solutions for a DC power supply. We were able to take advantage of an available solar powered battery cart to provide sufficient power for the DC voltage supply.

Project Morpheus:

Project Morpheus is a lunar lander vehicle which JSC is currently constructing in-house to gain knowledge, experience, and further develop technologies. Prior to the cold-flow testing conducted on the vehicle; I assisted engineers by assembling wire harnesses and terminating them with connectors. Due to the deadline for this aspect of the project to be completed, we worked until the wiring was completed. This process included crimping pins to the wire; inserting pins into proper placement within connectors, applying heat shrink boots to connectors, and assisting to make proper connections to various systems on the vehicle. The experience was truly a rewarding one as the cold-flow testing taking place the next day went well.

Figure 5: Assisting with wiring on the Morpheus Vehicle.

Resistor Bin Organization Project:

This was a small side project given to me by Jason Dugas, an electrical engineer working in the EP5 branch. In our building, there is a lab where various tools and components are located. My assignment was to have a series of various resistors ordered and then organize them within a bin drawer cabinet. This process proved to be tedious and required more work than originally anticipated. Dividers needed to be made for the bins which required me to submit an engineering order to the machine shop. I also created labels for each of the bins to indicate the location of the specific type of resistor. There were over 138 different types of resistors ordered and then separated into their respective bins.

Experience Gained:

My goal upon obtaining this co-op position at NASA was to gain practical knowledge of electrical engineering in a professional environment. The experience I gained here was tremendously worthwhile. Working within the Energy Systems Division at JSC has taught me many workplace lessons.

Project management was an experience I gained while at JSC. Setting forth objectives, organizing, and planning successful projects are a critical skill to obtain. While working on the aluminum wire study, I learned about ensuring goals are met. My mentor and I would often contact the test engineers at ESTA to make certain there weren't any delays and if there were any delays, how we could be of assistance.

Another great opportunity given to me was the presentation of the aluminum wire study to upper-level management. I was able to prepare a brief description of the study as well as answer any questions about the study. Being the only co-op student presenting information at the tour was a bit intimidating, however adequate preparation brought comfort to me and I went through the presentation smoothly.

Working with the design of the electrical power system for the ISRU Project presented another great learning experience. In order to design the electrical power system, we first had to understand more information about the loads. After finding the power consumption of the loads and also considering the voltage of the power supplies, circuit analysis was applied to find out the current passing through the wire. I produced top-level system diagrams to aid us through this process by using Microsoft Visio. This was my first time ever using Microsoft Visio, however the software was not difficult to use. The diagrams produced were representative so that the different people involved with the project could understand the drawing. This information helped us determine the different gauges of wire to use throughout the system. After selecting the gauges of wire, I learned about relays and fuses. Both of which are used for circuit protection. Reading datasheets proved to be extremely helpful during the process of learning about various components. The concept of a busbar and housekeeping power supply were also introduced to me.

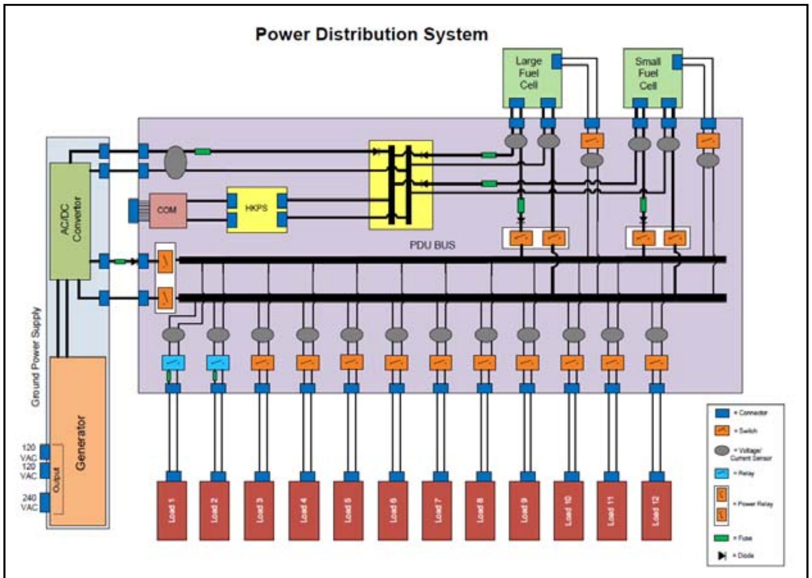

Figure 6: Top-level Electrical System Diagram for ISRU Project.

Once knowledge about the components was obtained, we began to select parts and create a bill of materials (BOM) for them. This process included searching for vendors and speaking to both sales and technical representatives frequently. Often times, a vendor has a minimum purchase quantity or lead-time for a particular part which has to be factored into the procurement process. If the lead-time is lengthy, then a different part may need to be selected due to deadlines within the stages of a project.

Another experience gained was the use of the software program Saber. Saber is used to model and analyze electrical power systems. My mentor had a wealth of knowledge using this software due to his experience working on the International Space Station of which the entire electrical power system has been modeled in Saber. Although typically used for large-scale projects, I learned the basics of the software by designing and analyzing simple circuits.


Figure 7: Taking a luminescence reading aboard the ISS Mockup.

Due to the availability of a lab, I often would take advantage of any learning opportunity presented. Jason Dugas and Frank Davies, both electrical engineers, would show me different equipment they frequently used around the lab and explain how I could use them. Due to the exposure gained from them, I have been inspired to start my own lab at home.


Figure 8: Morpheus Vehicle before completion.

Working hand-in-hand with other engineers on Project Morpheus was a good experience as well. The branch chief of my division, Karla Bradley, suggested that I help engineers with wiring because of an approaching deadline. I took advantage of the opportunity and acquired hands on skills by assisting them. Crimping wire with pins, using a heat gun, and inserting the wired pins into connectors were all new experiences for me. I plan on using these skills again in the future so it was great to learn the proper technique while doing-so.


Figure 9: My mentor, Sheikh Ahsan, and I aboard the Space Shuttle Simulator.

Of all the experiences gained, communication proved to be the most important. Although an engineer may specialize in a particular field, you must often coordinate and engage with others of different disciplines. Working with the Aluminum Wire Study, the ISRU Project, and the Electrolysis Innovation Day Project only verified how imperative it is to communicate with others. From TRR's to attending the preliminary design review (PDR) for the ISRU Project, I was able to truly see the collaborative effort of everyone involved. By use of conference calls, WebEx, and physical meetings, contributors from various centers were able to effectively communicate any changes or updates regarding the ISRU Project. As the different loads would change, the electrical power system design would also have to change. The diagram of the various loads produced in Microsoft Visio was often updated and revised. If everyone communicates effectively with each other, a successful outcome is more likely. Communication was also vital for me because I often sought out guidance from my mentor as well as co-workers. By communicating with my co-workers, I learned of the many different roles an engineer may function as within NASA. Hardware, software, testing, analysis, oversight, and research are just some of the responsibilities an engineer may have.

Personal Assessment of Experience:

Working at JSC was everything I hoped it would be. I took advantage of any opportunity for a tour or lecture available. These included lectures by Gene Krantz, a tour of the Robonaut Lab, and also the pyrotechnics lab. I even had an opportunity to be at the Mission Evaluation Room, known as the MER, during the shuttle launch of STS-133. I was invited by Mark Cummins, systems engineer, and sat behind console which gave me a behind the scenes perspective of the work which goes into a shuttle launch. Although being in an environment where equipment and software being readily available was great, the experts surrounding me proved to be the best available resource. For any question I had, my co-workers either provided an answer or guidance so I could find the answer myself. Being in an atmosphere where you can witness engineers work together to solve a problem was an invaluable experience and I can't describe how profound of an impact they had on me.

Figure 10: Mark Cummins, myself, and Frank Davies at the MER.

Future:

The co-op program at JSC requires technical co-op students complete 2 semesters and 1 summer of work. I plan on returning to JSC for my next co-op tour during the fall 2011 semester. I also hope to start obtaining lab equipment at home so I can start working on my own projects. I was introduced to microcontrollers while here and plan on learning more about using them during this summer. I hope to incorporate many of the lessons learned here while progressing through school. I plan on graduating in May 2013, and upon graduating I hope to be offered a full-time position as an electrical engineer at JSC. It will take hard work, however I am looking forward to the challenge.

Figure 11: JSC sign as seen from NASA Rd. 1.


Figure 12: Standing next to a T-38 Jet at Ellington Field.

References

Johnson Space Center, National Aeronautics and Space Administration (2011). Retrieved May 2, 2011, from http://www.jsc.nasa.gov/history.

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