NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Summer 2014 Final Report

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7/9/2014

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This summer was my fourth term working for NASA as a Career Pathways intern in the Ground Electrical and Electronics Branch of the Electrical Engineering Division of the Engineering Directorate (NE-E7) at the Kennedy Space Center (KSC). My branch primarily works on Command and Control (C&C) systems for Ground Support Equipment (GSE). We use Programmable Logic Controllers (PLCs) to control the various end items on the GSE. This is the same branch that I worked for in my past rotations, and I continued to work with my mentor Reggie Martin and the other engineers in my building. I got straight to work on my first day, continuing on projects that I worked on before as if I never left.

My primary project for this summer was to continue working on the Ground Operations Demonstration Unit - Liquid Hydrogen (GODU LH2) project, under the Advanced Exploration Systems (AES) program. This project is a full scale engineering test to develop a zero-loss hydrogen transfer system and to study a technique for hydrogen densification. Basically, the system will allow us to load a rocket without losing any hydrogen due to boil off in the transfer lines, and fit more hydrogen in a smaller tank due to increased density.

My role on the project was to help with the design, fabrication, and testing of the C&C system. Our system consists of a Local Control Distributor (LCD) and three Remote I/O's (RIO): RIO1, RIO2, and RIO3. The LCD is located in the command trailer in the clamshell building at our test site. I built and tested it last fall. It has the controller that stores and runs the software for the system. It communicates with several workstations via Ethernet so that users can manually control the system. An Ethernet line will be ran from the command trailer to RIO1 in the field with the test equipment, via RIO2 half way from the clamshell to the field. This summer I fit checked the LCD in the 19" server rack it will be installed in, as a preliminary check for when we are ready to install in the field.

I built RIO2 last fall, but the part of the project that was going to use it was cut due to funding limitations. The plan is that once the first part of the test is complete, the parts that were cut can be added back at a later time as continuing research. We still need to install RIO2 because Ethernet communication on conductor is limited to around three hundred feet, and it is approximately five hundred feet from the clamshell to the field. It has an Ethernet switch inside of it which will act as a repeater to boost the signal all the way to the field. I made minor modifications to accommodate the changes.

RIO1 is the main RIO that will communicate with all of the valve actuators and sensors outside in the field. This will control the flow of hydrogen through the system, as well as control nitrogen pneumatic control lines and helium purge lines. Reggie designed and built this cabinet, although I was able to make recommendations on component layout and wire routing. This summer I updated our Ground Integrated Schematic (GIS) to reflect the design that Reggie built. I also put together a wire run list to help with the channel designations on the I/O section of the GIS and installation. I worked with Reggie to determine where the penetrations for our cables will be located and how to connect them to the I/O modules.

RIO3 is located inside of an ISO shipping container that houses the refrigeration unit for the project. We decided to build a small RIO for the ISO container to control everything inside of it so that we only needed to make one penetration into the container for Ethernet communication. I designed, built, and tested RIO3 this summer, and added the appropriate drawings in the GIS. This included determining what end items I had to control, what kind of signals they require, and what kind of I/O modules I needed for my PLC chassis. This RIO has several AC signals and power, and is in a relatively noisy environment for Electro Magnetic Interference (EMI), so I had to plan the routing of my wires. I decided to have all of my power come in at the top of the panel, and I sent all of the AC power and signals down the left vertical raceway and all of the DC power and signals down the right vertical raceway to the appropriate terminal blocks. This separation will help to reduce the chance of noise on the DC signals.

Overall, my primary responsibility was to handle the day-to-day design and prototype work for the project. I was responsible for prototyping the hardware, assisting the design of the system, and fabricating the connectors that will communicate with the end items. At the beginning of the summer we had a goal to install our system in the field in early August, after testing all of the RIOs with the LCD in the lab.

In order to design the system, I needed to know what we were supposed to control and how to actually control it. I was given a list of end items that we needed to control and went about prototyping how to wire them. I gathered data sheets on the end items and found wiring diagrams. I then got samples of the various valve actuators and other hardware so that I could wire them to a test chassis in the lab. I learned about analog vs discrete signals, AC vs DC signals, and 4-20mA vs 1-5V analog signals. I used what I learned in these prototypes to verify the design of the RIOs.

Last fall, my primary focus on this project was to order the wire and connectors needed to build the cables for the system. This summer, the parts I had put on the order began to arrive, and my new focus was to verify that they were correct and get them fabricated. Because there were some changes made to the system when I was gone, and because we were able to get some equivalent connectors from the Launch Equipment Test Facility (LETF) and the Cryogenics Test Lab (CTL), I had to order a few additional parts.

Getting the cables fabricated has been the biggest challenge so far, although it was mostly a project management issue. The original plan was to have our cable/connector team create cable subassembly drawings to send to the cable group, along with the hardware we procured. The cable group was going to build the cables for us, but our project manager tasked us to look into building the cables ourselves in order to save money. As the drawings were being created for the cable group, we looked into the process and determined that we could crimp and solder the conductors to the connectors, but we don't have the proper equipment to pot and mold the cables. We would still need the cable group to do this part for us, which is the majority of their cost.

Potting is a process where a compound is poured in the backshell of a connector in order to make an airtight seal. This makes the connector rated for use in a Class I Div II hazardous environment (explosive gas, not present under normal operating conditions). Molding is a process where an epoxy is filled into a mold to create a strain relief on the backshell of a connector. These are standard processes for fabricating cable.

It took several weeks to determine how we were going to proceed, and this contributed to pushing back our August installation goal. Other contributing factors were that we had to wait for another set of procurements to go through including additional connectors, Ethernet switches, and Ethernet communication modules. We were going to use modules from old shuttle cabinets, but they did not support the Ethernet/IP communication protocols that our current PLCs use. This meant that we were delayed in finishing the fabrication of the RIOs and performing our integrated test in the lab.

This summer I had more responsibility on the project and got to see the design process from the design engineer's viewpoint all the way to the project manager's viewpoint. I had to set up meetings and interface with the fluids team members of the project. I had the chance to set up and run a teleconference with the manufacturer of the refrigeration system and with team members both here at KSC and at the Glenn Research Center (GRC) in Ohio. The primary goal of this teleconference was to ask questions about the interface to the refrigerator.

I had the opportunity to see some Verification and Validation (V&V) testing on a system called Crew Module Ammonia Servicing Subsystem (CMASS). CMASS will load liquid ammonia into the Orion Multi-Purpose Crew Vehicle (MPCV) that will cool the heat shields during its reentry test on Exploration Flight Test 1 (EFT-1) in December. My project last summer was to verify the design of the Kennedy Ground Control System (KGCS) Mobile Data Cart (MDC), a standalone mobile LCD with Record and Retrieval (R&R) capabilities. This cart is being used to control the CMASS hardware. A V&V test is a very formal test that is used to verify that the system operates the way it was intended and to buy off the formal requirements of the system. I learned a lot about the design cycle of a product and troubleshooting during operations. I even assisted in performing a water flow test as a component level verification of a scale that is used in the system.

I was also able to take advantage of various opportunities to see and learn about the spaceport and the wide spectrum of work that is going on. One of the most rewarding things was to participate in the annual Family Day. Last fall, I repaired the Constellation Test Article, a model of the Ares I that is controlled by a PLC and can go through an entire simulated launch sequence, from filling fuel tanks to releasing the umbilicals. I helped to get it ready for display in our lab on Family Day. I had a great time bringing my parents and brother to see what I do.

I also got to go to training, Hydrogen Safety Training, and I got to see many different facilities at KSC during my work term, including the MOSB, LCC, and LC39-B. I have learned a lot about how the PLC I/O modules work, and how they should be wired to control devices. I was exposed to a lot of project management decisions and critical testing. I made it one of my goals to work with more of the engineers in my branch, and I was glad to be given real responsibilities on my project.

This has been a very productive and rewarding summer. I really enjoyed being welcomed back as if I never left, and I appreciated the opportunity to take more responsibility for my project. I have learned many lessons that will help me throughout my future career.