

NASA KSC – Hardware and Software Engineering

NASA KSC/Intern Final Report – 2019 – 04/10/2019



Hardware and Software Engineering Spring 2019 Internship Final Report

Student Name: Greg Anderson
Academic Level: Undergraduate Senior
Academic Major: Electrical & Mechanical Engineering
Academic Institution: George Mason University

Mentor Name: Jill Giles
Mentor Job Title: Computer Engineer, AST
Org Code/Branch: NE-XS
Division: Exploration Systems and Operations
Directorate: Engineering

Hardware and Software Engineering

Greg D. Anderson¹

George Mason University, Fairfax, Virginia, 22030

Nomenclature

LCS	= Launch Control System
SLS	= Space Launch System
EDL	= Engineering Development Lab
RPS	= Record and Playback Subsystem
KGCS	= Kennedy Ground Control Subsystems
PLC	= Programmable Logic Controller
CDL	= Control System Development Lab
GUI	= Graphical User Interface

I. Introduction

My internship this spring provided me the opportunity to work in two groups that contribute to the Exploration Ground Systems program. This allowed me to gain different perspectives of the program while also allowing me to gain new knowledge and experiences. The first group I worked in was Record and Playback Subsystem (RPS); this group supports the testing and operation of the Space Launch System (SLS). RPS records all the data from the ground control systems and the subsystems on SLS. This data can then be played back and analyzed, allowing for data to be used for troubleshooting any errors or anomalies. The first project I was given was to automate updating displays. This is done by hand and takes a team of two people to complete. The displays allow for a Graphical User Interface (GUI) for any user to see any data set. Generally, the data displayed is from a specific subsystem of the SLS. Each data or string of text on the GUI is linked to a specific location. If this location changes or is removed, then the corresponding GUI element will either read the wrong data or no data. Because the updating of locations has been done by hand, there has been an increased chance that there are errors in the updating process; automating this process will mitigate these errors.

The second project with which RPS tasked me was to automate how engineering reports are created. RPS engineering reports are large files that contain all the information of a data stream over a time. Due to the size of the files, it is difficult to analyze all the data; with my new engineering report automation, the file size is condensed, making it more manageable to analyze. The reporting tool allows the user to pick specific data streams, choose a time band, and chose an output format.

The second group I worked for was Kennedy Ground Control Subsystems (KGCS). The first project I was tasked with was to propose and create a new power distribution layout of the Control System Development Lab (CDL). The lab specifically works with programmable logic controllers (PLC) and integrating them into the ground support systems for SLS. The power distribution of the lab is not documented, which is troublesome because if a circuit breaker is tripped, the effect on the lab is unknown. The diagram I created will allow lab mangers to know how everything is powered and which breakers are used. The second part of the project is to propose a new layout that will be more efficient so that if a breaker is tripped it won't take down a large section of the lab. This will increase the safety of the hardware if an outage or surge occurs. The second project I was given was to create a PLC trainer for new interns or employees. When a new hire starts, they take online PLC training. Although this is helpful for a basic overview, it doesn't teach them how to actually interact with and program PLCs. The trainer I am creating will allow a user to experiment with different components and modules used in real-world scenarios.

¹ Computer Hardware Engineering Intern, NE-XS, John F. Kennedy Space Center, George Mason University

II. Goals

Below are the goals for each project during my internship. The group where this work was performed is listed in parenthesis for each goal.

1. Automating the Display Making Process (RPS)
 - a. Understand how the displays are made
 - b. Understand how to interface with the software used to create the displays
 - c. Create a program that takes one display and changes a property
 - d. Complete the program to update all elements
 - e. Create a GUI
 - f. Test the program and fix any bugs that arise
2. Hardware Configuration Document (RPS)
 - a. Understand the documentation process and layout
 - b. Find all the properties and hardware that need to be documented
 - c. Create a draft of the document to be reviewed
 - d. Update as needed and submit once approved
3. Automated Report (RPS)
 - a. Understand what data channels and format are needed
 - b. Understand how to interface and create a plugin with the software used
 - c. Create GUIs that a user can use
 - d. Optimize the algorithm of the code to make it more efficient
 - e. Test to make sure the code is working properly and compare it to test cases
 - f. Test the program and fix any bugs that arise
4. One-Line Power Configuration Drawing (KGCS)
 - a. Understand requirements and lab layout
 - b. Gather all needed information
 - c. Create one-line drawing with update numbers
 - d. Get drawing reviewed and change as needed
5. PLC Trainer (KGCS)
 - a. Understand PLCs and their associated software
 - b. Understand project requirements
 - c. Research PLCs and the hardware needed
 - d. Create electrical and mechanical drawings
 - e. Order parts
 - f. Create documentation on building and troubleshooting
 - g. Build and test if time permits

III. Approach

A. Display Automation

In the initial weeks of the internship, I read about telemetry standards and networking protocols to obtain a better understanding of the data and processes that RPS handles. Employees from the communication department came to RPS asking for displays to be updated with new parameters. I assisted with making these updated displays manually. This helped me better understand how displays are made and how each number or text string is shown on the user interface. Each number or string of text is connected to a parameter that links to a specific packet of raw data from any sensors or subsystem in LCS or on SLS. These displays are used for testing and launch operations, so it is imperative these displays are created correctly. If one parameter is incorrect, it can cause data to be not be shown or display data of another element. Overall this gave me a better understanding of the creation and updating of a display. I was tasked with automating this process so instead of the display taking a team of two people several hours to update, it would take minutes or even seconds to perform the updates. I started by gaining an understanding of how the files are created and the format that the file follows, allowing me to research how to imitate this in a specific programming language. Using this information, I built a program that ingested the original display, created a copy, and applied the new parameter changes. The program outputs all the differences in parameters and, once the changes are applied, outputs what was changed. This helps the user understand what was updated, changed, or removed between the two displays. After completion, I tested the program against the manual process and fixed the bugs discovered to ensure it met all requirements.

B. Hardware Configuration Document

The next project that RPS assigned me was to document the hardware configurations of each component. This allows RPS to either recover the configuration or apply the same configuration to a new component if the hardware gets wiped or broken. The documentation also shows which hardware components are configured for RPS and which hardware is configured by the manufacturer, allowing the group to know which components need to be sent to the manufacture if there is a problem, or if they need to fix the configurations themselves. For this task, I determined which hardware components needed to be documented and then researched what was out of the box and what was configured.

C. Engineering Report Automation

The last project that RPS gave me was to create a plugin for a software suite to output a formatted and condensed version of raw data. The software can output the raw data but doing so creates a large file that causes most computers to crash and makes it difficult to analyze the data for any trends or differences. The plugin that was created allows the user to select which data is used and how it is formatted, allowing it to be easily analyzed. To do this I needed to research and understand how the software creates the raw “dump” of the data, which allowed me to recreate that behavior in my plugin. Once the plugin was created, it was given to the RPS team to review and to determine what elements needed to be fixed, removed, or added. I fixed the issues discovered in the review and then developed test cases to see if the software operated as required. The program worked as designed but was much slower than the raw data dump. The raw data dump took two minutes to complete, but my initial plugin took several hours to configure and format the data. Because of this, I modified the code to make it more efficient, which reduced the run time to an hour.

D. Lab Power Configuration Document and Diagram

While working in the KGCS group, my first task was to create the one-line power configuration drawing of the CDL and also create a new proposed power configuration layout. I was given a tour and access to the lab to obtain an understanding of the lab’s layout and how it operates. CDL has many development benches; each bench has a workstation, PLC hardware, monitor, and other miscellaneous hardware. I created a detailed layout of the lab that includes these details: the layout of the rooms, benches’ power source, and what breakers are being used. Once I had the overview layout, I determined the power rating for each breaker and bench power strip. This rating represents how many amps can run through the breaker at one time; if the amperage is exceeded, it will cause the breaker to pop and anything connected to that breaker will lose power. Once all the information was obtained, I created the one-line diagram of the power distribution. The one-line diagram provides the lab manager or technician with a way of determining if there are too many benches connected to the same power source. The second part of this project involved improvements to the layout. The new layout should try to limit the number of benches connected to a single breaker, so that if a breaker is blown, it won’t shut down much of the lab. Once I completed the diagrams, I gave it to the CDL managers for review.

E. PLC Trainer Design

The next project that KGCS assigned me was to create a PLC trainer to help users become familiar with PLC hardware and how to program them. The trainer layout was taken from a ladder logic programming handbook for the specific PLCs. This handbook was used in a class for employees who work in the CDL to help them learn how to use PLCs. The trainer I am creating and designing will mimic the ones they used, while also including the ability to expand and improve upon them later. Using the diagram included in the handbook, I found similar parts online. Once the parts were procured, I created a wiring diagram that will help another engineer understand the connections. I also created a mechanical drawing for the enclosure of the trainer so a new hire could easily set up the trainer and familiarize themselves with it. The last thing I did was to create a document to help the end user build and troubleshoot their own trainer setup.

IV. Conclusion

While working in the RPS and KGCS groups, I experienced two of the many facets of the Exploration Ground Systems program. RPS focused on the operational side, while KGCS showed me the development and integration side of SLS ground control. The projects I completed this spring semester allowed me to help the teams to become more efficient while also teaching me about new technologies and techniques.

Acknowledgements

I would like to give my deepest thanks to my mentors Jill Giles and Jamie Szafran. These two taught me a lot about NASA, SLS, LCS, and the NE-XS branch. They also helped me explore other projects to gain a well-rounded understanding of the engineering process. I would also like to thank Doug Johnston, Melanie Johnson, and the entire RPS team for teaching me how the firing rooms and RPS work. They taught me new technologies and new ways to look at tasks and how to improve on them. Last, I would like to thank Elias Victor within the KGCS group, who taught me how PLCs work and efficiency can be improved while adding security and redundancies to systems. Finally, I would like to thank the Education Office for giving me this opportunity.