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Electrical Engineering and Astronomy/Astrophysics
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I will be returning to campus for the Fall 2010 semester.

Kennedy Space Center: Constellation Program Electrical Ground Support Equipment Research and Development

ABSTRACT:

The Kennedy Space Center (KSC) is NASA's spaceport, launching rockets into space and leading important human spaceflight research. This spring semester, I worked at KSC on Constellation Program electrical ground support equipment through NASA's Undergraduate Student Research Program (USRP). This report includes a discussion of NASA, KSC, and my individual research project. An analysis of Penn State's preparation of me for an internship and my overall impressions of the Penn State and NASA internship experience conclude the report.

THE COMPANY AT WHICH I WORKED:

This spring, I interned for NASA at the Kennedy Space Center (KSC) on Merritt Island in Florida. The National Aeronautics and Space Administration (NASA) was established in 1958 by President Dwight D. Eisenhower amongst the backdrop of the Cold War and the Soviet Union's launch of the first artificial satellite, *Sputnik*, the previous year. The predecessor to NASA was NACA, the National Advisory Committee in Aeronautics, which had been researching aeronautics and flight technology for the previous 40 years.¹

NASA is comprised of 10 field centers, reaching from California to Florida and Ohio to Texas. NASA Headquarters is located in Washington, D.C. and provides guidance and control to the organization under the authority of the NASA Administrator (currently Charlie Bolden).¹ NASA's work is divided into four mission directorates:¹

- Aeronautics – researches and develops new flight technologies that enable NASA's exploration activities, as well as providing testing facilities for commercial aviation.
- Exploration Systems – designs and develops new technologies and spacecraft for human and robotic exploration.
- Science – studies the Earth and provides weather information, explores the Solar System, and uses space telescopes to study the depths of the Universe.
- Space Operations – provides crucial enabling technologies and support through the space shuttle, the International Space Station (ISS), and flight support in mission control.

NASA's budget currently stands at \$18 billion, or roughly 0.6% of the federal budget, surprisingly low considering NASA's many benefits to society.

Though NASA itself employs roughly 17,000 civil servants, 40,000 contractors also work at the various NASA centers and provide much needed support.² Holding true to its reputation,

NASA is ranked third among large federal agencies as the best place to work and consistently receives positive reviews from its employees.³

In 1962, the Launch Operations Center was authorized by President John F. Kennedy. It was renamed the Kennedy Space Center in 1963, in honor of the late president. The earliest years of KSC saw the development and progress of Project Mercury, NASA's first step to meeting Kennedy's challenge of landing men on the moon and safely returning them to Earth by the end of the decade. The goal of Project Mercury was to place manned spacecraft in orbit around Earth, investigate human performance in space, and safely return the astronauts to Earth. Project Gemini followed with 10 manned flights in 1965 and 1966. This more ambitious project used a two-man spacecraft to practice rendezvous, docking, and astronaut extra-vehicular activities. Gemini was followed by Project Apollo, which had the ultimate goal of moon landings. An \$800 million facility, Launch Complex 39, was built at KSC to accommodate the 363-foot Saturn V rockets which would be needed to launch men to the moon. Two launch pads, Pads A and B, were completed along with the Vehicle Assembly Building (VAB), a 130 million cubic foot building where the Saturn V rockets would be assembled and prepared for launch. Project Apollo would see 6 moon landings by 1972, with Neil Armstrong and Buzz Aldrin the first two men to walk on the moon during the Apollo 11 mission.

Since the Apollo years, KSC has supported other launches, including the Space Shuttle program, which began in 1981. There have been 131 shuttle launches since the program's inception, with 3 of the 5 orbiters still in service (*Endeavour*, *Discovery*, and *Atlantis*; two orbiters, *Challenger* and *Columbia*, were tragically destroyed in 1986 and 2003, respectively). KSC is home to the Shuttle Landing Facility (SLF), a 2.9 mile long runway that serves as the primary post-mission landing site for the shuttle orbiters.

The Kennedy Space Center's current tasks focus on integration of ISS payloads, the end of the Space Shuttle Program, and the beginning of the Constellation Program, which was established by President George Bush in 2004 to send Americans to the moon and on to Mars. On October 28, 2009, NASA launched the Ares I-X rocket from Pad 39B, a precursor test for the Ares I rocket that would carry humans to the moon. However, the end of the Space Shuttle program later this year will cause significant downsizing of the KSC workforce. Furthermore, President Obama's 2011 budget proposal to Congress ends the Constellation Program, instead relying on commercial companies to ferry astronauts to the ISS.

For my internship, I worked for NASA in the Electrical Design Branch of the Engineering Directorate at KSC through the Undergraduate Student Research Program (USRP). Working in the Controls Lab of the Engineering Development Lab, I had a few small individual tasks, all focused on the development of electrical ground support equipment for the Constellation Program.

MY WORK ASSIGNMENT:

My first main job responsibility this spring was to understand the role of programmable logic controllers (PLC) within the Kennedy Ground Control System (KGCS). KSC is using PLC's to command, control, and monitor the health of the wide array of end instruments (sensors, actuators, heaters, etc.) that will make Constellation Program launch operations possible. To accomplish this task, I needed to go through tutorials on RSLogix 5000, a software program by Rockwell Software that allows users to program PLC's. After the tutorials, I set up my own test rack with Allen-Bradley PLC's to familiarize myself with hands-on PLC operation. I then conducted a series of tests to measure the command and control effects of latency and jitter on the Constellation Program's electrical ground support equipment network. Latency is the time response between when a command is sent from the Launch Control Center (LCC) to the time the command is received at the launch tower. Jitter is the variation in this time response. Both latency and jitter are important, since they indicate the timeliness and consistency of communications.

My second major responsibility was to synchronize the KGCS PLC clocks and time stamp the data packets sent to and from the LCC using the IEEE 1588 Precision Time Protocol (PTP). The actual testing will not take place until late May, but I was involved with the preparation and planning for the testing. Time stamping is significant because it allows for event reconstruction and documentation of communications in a synchronized time system.

This internship was more pure electrical engineering than my internship last summer with NASA at the Goddard Space Flight Center. At Goddard, my project on the James Webb Space Telescope was a multi-disciplinary combination of my degrees in electrical engineering and

astronomy/astrophysics. For this internship, my tasks related most closely with control systems and communications.

As with Goddard, although Penn State classes provided the background information necessary to learn new concepts, the on-the-job training demonstrated what knowledge was needed. Some of the work was challenging, as this was my first real-world hardware experience. Taking my EE senior design course next year, either EE 403W or EDGSN 497D, will provide me with more hands-on engineering experience. At the beginning of my internship, I did not feel like I was adequately prepared to work on a hands-on project and I think added experience from my senior design class will prove helpful in the future. Most EE labs at Penn State simply instruct students on what steps to take to achieve a desired outcome, rather than allowing the students to think and design on their own. However, on the same token, every job in the engineering world is unique and requires specific training and it is unrealistic to expect students to have extensive prior experience. It is more important to have the ability to learn on the job and adapt to the project at hand.

This internship confirmed that I like working with control systems, similar to my honor's/master's thesis research, which is on the use of infrared detectors to find planets orbiting M dwarf stars. Due to limited scheduling space, I will not be able to take any specific EE control system classes, but control systems can be applied to most any engineering specialization area. However, I do know that I will work in the space industry for my career. While at KSC, I also took advantage of the opportunity to talk to Air Force officers from Patrick Air Force Base about officer opportunities available with Air Force Space Command.

Written communication skills were necessary for my final USRP report. I was required to write a 10 page technical paper in AIAA journal format describing in detail the work that I did

at KSC during my 15 weeks. Verbal communication was needed to interact with various workers, including my mentor Reggie Martin, so that I could ask questions about the operation of the Kennedy electrical ground support network.

MY OVERALL EXPERIENCE:

This internship provided a good contrast to my experience at Goddard. Goddard is a science research center that designs and builds earth and space science satellites. KSC is operations-focused, with the goal of launching humans into space. However, the pending cancelation of the Constellation Program loomed large this spring. Many of the contractors that I worked with risk losing their jobs if the Constellation Program is indeed canceled. On a daily basis I received updates on the future of the Constellation Program and NASA human spaceflight. I grew up wanting to work in human spaceflight and to apply to be an astronaut, but the 2011 budget proposed by Obama would drastically change my plans to work in human spaceflight at NASA.

Regardless of the 2011 budget proposal, this internship made me realize that it is important to enjoy the work that one does on a daily basis. Though I learned a lot about electrical ground support equipment while at KSC, I enjoy working on earth or space science satellites more, since they offer the opportunity to apply a wider scope of knowledge. Though I was technically working in support of human spaceflight, I would rather have a non-human spaceflight job that better fits my interests at a place like Goddard. With all of the uncertainty surrounding the future of U.S. human spaceflight, this is also the safer career move.

As previously mentioned, I took advantage of the opportunity at KSC to talk to Air Force officers from Patrick Air Force Base who were stationed at Cape Canaveral Air Force Station. Considering the political turmoil currently surrounding NASA, I am leaning towards joining the Air Force after graduating from Penn State. I met with Scott Traxler, a former Air Force Lieutenant Colonel, who now works as the Technical Director of the 45th Launch Group, a unit of the 45th Space Wing based at Patrick Air Force Base. I also spoke with Captain Mickey

Black, a Penn State grad currently serving as a developmental engineer for Space Command. Both Mr. Traxler and Captain Black were extremely helpful in answering all of my personal and career-related questions about joining the Air Force. After taking everything into consideration, I think it will be best for me to serve in the Air Force for an undetermined amount of time and then make the transition back to NASA upon leaving the service.

For the summer of 2011, I will have the option of returning to Goddard, so I am speaking with people there about potential internship positions. I am also considering the Air Force's Space Scholars Program, which offers the opportunity to work at Air Force Research Labs in Albuquerque, New Mexico or Bedford, Massachusetts.

My particular work assignment could have been improved if I would have had a more clearly defined objective. I never had a major project, only a couple of smaller tasks that would not result in any publishable research. I enjoyed learning about PLC's and the KGCS network, but the two tests that I prepared for during the majority of my internship - a command, measurement, and event test, as well as the 1588 timing test - were both postponed to the end of May, after I leave KSC. Though that is not anyone's fault in particular, it is disappointing that I will be unable to perform two of my major internship tasks. Much of what I did for the past 2/3 of my internship was in preparation for these two tests. Although I can write about preparing for the tests in my USRP final report, I will not have any significant results to analyze.

NASA's USRP could also use some improvements for the spring (and probably fall) semester. I realize that the majority of interns work for NASA in the summer and that is when most events are scheduled, but the KSC Education Office did very little for its students (only 6 of us) this spring. Our internship coordinator only contacted us once within the first 10 weeks of the internship. Last summer, I was fortunate to be in the NASA Academy at Goddard, where we

went on trips to other NASA centers, commercial space companies, space policy organizations, research labs, etc. We had weekly dinner speakers from throughout the space industry visit our residence, as all of the interns lived together. Furthermore, we worked on a group project, teaching us teamwork and leadership skills. I even had the opportunity to be in Goddard's 50th anniversary fashion show! The NASA Academy was very interactive and organized, a stark contrast to the hands-off approach of the USRP. I understand that the USRP more accurately reflects the real work environment without the extra activities, but the point of an internship is to be interactive. The USRP failed to engage its own students with each other, much less introduce us to other interns or co-ops in different programs.

The highlights of my time at KSC were definitely the launches that I was lucky enough to watch. Last summer, I was at two scrubs of the Space Shuttle *Endeavour's* STS-127 launch. However, this spring I saw the launch of the Space Shuttle *Endeavour* (STS-130), the Solar Dynamics Observatory on an Atlas V rocket, the GOES-P NOAA satellite on a Delta IV rocket, the Space Shuttle *Discovery* (STS-131), and the Air Force's X-37B Orbital Test Vehicle on an Atlas V rocket. To the KSC Education Office's credit, they did provide car passes for us to view a few of the launches. I was also able to visit Pad 39A when *Discovery* was being prepared for its launch, as well as see *Atlantis* as it rolled out to the pad for STS-132. *Atlantis* is scheduled to launch on May 14th, my last day at KSC. On a personal level, I played on a KSC intramural softball team and I enjoyed the chance to finally play baseball/softball again after retiring from competitive baseball 10 years ago. As of today, our softball team is 4-4 and I have mostly played right-center field, posting a .483 batting average at the plate.

For Penn State's co-op program, I do not think that students on an internship/co-op in the spring or fall semester should be forced to register for one credit to remain a full-time student.

Maybe this is a legal issue for students to be required to stay full-time, in which case, there may not be much that can be done about the situation. However, I do not think that it is fair for students to be forced to pay over \$600 for the one credit, when I do not need any internship credits to graduate. Other than that, I was fine with the mid-term evaluation and this final report. Serving as a College of Engineering Cooperative Education and Professional Internship Envoy, I stress the importance of internships to students and I look forward to my next internship in the summer of 2011, whether that internship is back with NASA or with the Air Force.

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