NASA International Internship Report to NIHERST

Jason Renwick

Brief Introduction

Jason Renwick is a student in the Department of Electrical and Computer Engineering at the Faculty of Engineering, The University of the West Indies (UWI), St. Augustine Campus, Trinidad and Tobago. His interest in computing began when he became a certified A+ Technician in 2008 and it became firmly instilled when he attended UWI's Department of Computing and Information Technology Bootcamp in 2011.

In sixth form, while at Trinity College Moka, Maraval, he was president of the student council, represented the school at the 10th Annual Trinidad and Tobago Youth Parliament and had participated in the Maths Olympiad over the years. He was also an avid table and lawn tennis player, a member of the dragon boating team and participated in interschool chess and scrabble competitions.

He is a Past President and, currently, a senior member of the Trinidad and Tobago Astro Club. He teaches astrophotography and has presented at NIHERST's Astronomy nights.

Jason participated in NIHERST's Caribbean Youth Science Forum (CYSF) 2012 and returned as a CYSF host in the following year. In 2014, he was awarded the Fall International Internship (I^2) at the Prognostics Center of Excellence, NASA Ames Research Center at the Moffet Federal Airfield, Silicon Valley in California. After completing a successful internship, he returned in Spring 2015 to continue his research for a second internship period at NASA Ames. He was awarded the inaugural Rudranath Capildeo Young Scientist Award as the NASA Intern 2015 by the Central Bank of Trinidad and Tobago.

Overview of the Internship Experience

Dates: 31 August 2014 – 20 December 2014 and invited to return 7 February 2015 – 30 May 2015

Location: Prognostics Centre of Excellence, National Aeronautics and Space Administration (NASA) Ames Research Centre, Mountain View, California, USA.

Mentors: Dr. Chetan S. Kulkarni and Dr. José Celaya

Outcomes: (1) Academic Poster entitled "Analysis of Electrolytic Capacitor Degradation under Electrical Overstress for Prognostic Studies"

(2) Conference Paper:

Renwick, Jason, Chetan S. Kulkarni, and José Celaya. 2015. "Analysis of Electrolytic Capacitor Degradation from Overstress for Prognostic Studies." Paper to be presented at the Annual Conference of the Prognostic and Health Management Society, Coronado, California, 18-24 October, 2015.

(3) In-depth scientific enquiry, that is, greater knowledge into international recognised research performed on capacitors

(4) This research may lead to further studies in this field being performed in Trinidad at The University of the West Indies.

The internship commenced on 1 September 2014. The transit time was approximately 20 hours long and involved three connecting flights and a taxi ride. The Ames campus, one of a dozen or so NASA facilities around the US, is approximately

2,000 acres. It encompasses a golf course, military base, research park and research centre.[1] It is one of the largest scientific facilities in California and is a historical monument to scientific and military communities.

The Ames Research Center was commissioned in 1939 under the title of NACA (National Advisory Committee for Aeronautics, the predecessor to NASA).[2] There have been many scientific breakthroughs since its establishment such as early development of the "Internet" and, more recently, spacecraft development. During the internship, I was a member of the Diagnostics and Prognostics group. The group was formed as part of the Prognostics Center of Excellence, the leading prognostics facility in the world. Some major discoveries on battery life have been revealed in the prognostics laboratory.

A pleasant surprise that I encountered while at Ames was the high interest in the Caribbean and the life of a West Indian. Most people were unaware of the lifestyle or existence of Caribbean. Very often, I found myself giving a history of Trinidad and associated islands.

Activities Undertaken during the Internship

Research activities

The work I undertook involved aging experiments on electrolytic capacitors. In order to conduct these experiments required the development of an experimental test bed. This required connecting and troubleshooting an electronic circuit comprised mainly of variable resistors, operational amplifiers, capacitors, printed circuit boards, a function generator and a power supply. It was assembled so that the capacitors would

[1] See layout of NASA Ames Research Center at http://sun.stanford.edu/LWS2013/NASA_Ames_Reseach_Park_map.pdf

[2] For a brief history of NASA Ames Research Center see https://www.nasa.gov/centers/ames/about/history.html#.VgsluflViko

be cyclically charged and discharged at a rate of 200 mHz. The requisite knowledge of analog circuitry was gained while studying at UWI as well as further research and in-depth reading done during the internship.

Once the capacitors began aging, a physical system was required to interface between the capacitors and the data acquisition units. This system was based on hardware from National Instruments.[3] The data acquisition was set up to sample voltages from the circuit at a rate of 20 hertz. The experimental data was recorded via a program developed in advanced software called LABview. This involved another steep learning curve as I was required to learn LABview in order to use/develop the program. This program acted as the software interface between the physical circuit and the computer recording the experimental data.

The sampling of the circuit led to a large amount of experimental data being collected. The focus of the second internship in Spring 2015 was to analyze the stored data. This involved extensive mathematical programming which was done in MATlab, such as applying mathematical filters to the voltage data. Once the data was filtered and rigorously checked for errors, inconsistencies etc., advanced prognostic analysis was then conducted.

Training/Professional Development

At NASA, safety is viewed as an utmost priority. Thus, in order to conduct experiments in the SHARP (System Health Analysis and Reliability Physics) Lab required in-depth lab safety training before utilizing the lab equipment. This training focused on electrical and chemical safety.

[3] National Instruments – see http://www.ni.com/company/

Group meetings

At University and in the workplace it is normally said that communication is directly linked to the success of any project. In the Prognostics Department we considered all projects as group work since at any time, you could seek the assistance of another group of researchers for your current projects. To promote comfort and input from group members, we had a fortnightly group meeting. At these sessions, each active project would be presented by the relevant lead scientist. During and after the presentations, those attending would comment, question and advise, accordingly. These meetings were very helpful and useful towards the success of the project.

Talks/Seminars

Ames Research Centre is well known among the NASA centers for accepting the most concurrent interns. It was also the first NASA center to host international interns. With such a large intern population, the Ames education office was well prepared to facilitate seminars and talks with renowned scientists. During my internship, I attended several such gatherings. One memorable lunch-time talk was scheduled with Dr. Seth Shostak, the director of SETI (Search for Extra-Terrestrial Intelligence). He elaborated on developments and experiments being undertaken towards finding intelligent life in space.

NASA's Ames Research Center 75th Anniversary

On October 18, 2014, NASA held an Open House for their 75th anniversary. This involved opening the gates of the research center to the public. Therefore persons from all walks of life could visit Ames and view the experiments being performed. The open house attracted celebrities and government officials. It also gave me the opportunity to explore other laboratories that are not usually accessible to non-US nationals.

Lessons Learnt from Internship Experience

During the internship, I was exposed to an extremely professional work environment. In order to adapt, an exceedingly high level of work ethic was required. To achieve this remarkable work ethic, I adopted a keen sense of discipline and time management. By demonstrating that I was dependable, had an earnest willingness to learn as well as the ability to adapt to the professional environment and their work culture, my supervisors were prepared to give me increased responsibilities which led to my being invited to return in Spring 2015 for a second internship.

Networking is normally regarded as one of the key outcomes during any internship. While at NASA, this was done with ease as most of the scientists were willing to socialize and have informal meetings. Also, my research group often had social meet-ups, such as group lunches or dinner. The weekly talks with prominent scientists and interns which the Ames Education Office organised also allowed for valuable interaction and sharing.

Academically, I was introduced to methods of scientific research of which I did not have previous experience. Although I lacked prior knowledge on some aspects of the research process, my mentors were remarkably willing to assist me to learn and understand what was required to get the work done.

With regard to the personal aspects of the internship, we were required to provide our own food and transport as well as do our laundry. Since the campus was quite large, cycling was an efficient method of moving around. This involved purchasing a bicycle and utilising Google's extremely efficient directional software. Occasionally, if we chose to visit another city, like San Francisco, we would utilize the public transport utilities, such as trains. For daily meals, our two main options were either utilize the Ames cafeteria or improve on our cooking skills. The latter involved

regular grocery shopping. We did sample some of California's international (often spicy) cuisine occasionally.

Leisure time spent at coffee shops proved to be an excellent method of making friends and interacting with Silicon's brightest and best. Being in this fast-paced/community of start-ups and the best of technology companies (Google, Facebook), was inspiring and facilitated an opening of the mind, unparalleled thus far in my life. The work force at Ames was decidedly international in flavour and this exposure led to making friends from various parts of the world.

Sports are promoted by NASA as an important part of daily routine, thus sporting facilities and gyms are provided and schedules allow for getting involved in individual activity and team games. Volley ball and lawn tennis were my regular choices.

Way Forward

As stated by the Prognostics and Health Management Society, "Prognostics is the estimation of remaining life of a component or subsystem". As modern lifestyles become more techno-centric, the need for prognostics is quickly becoming abundantly apparent. Various engineering disciplines have begun to incorporate more electronics in their work. With this rise in electronic use, prognostic scientists are being increasingly employed in engineering disciplines outside of electrical engineering and is extending to fields other than engineering as well.

As the main outcome of prognostic research is an estimation of remaining useful life, the application of prognostics can lead to a wide range of usable information. Firstly, the resulting information on remaining useful life can lead to superior decision

making. This notion has become very popular among software engineers who specialize in artificial intelligence. Any additional information software can be used when making a decision is extremely valuable because it allows programs to better mimic the decision process done by human beings. An example of this is reconnaissance rovers on exploratory missions in the solar system. In harsh environments, unlike that of earth, the inexperience of the scientist can be near detrimental to a mission (as demonstrated by the Philae spacecraft landing). Rovers always need to reassess their position, environment and potential variables that may affect their actions. This sort of decision making is not limited to science as prognostic data can also be utilized in economics and even competitive sport.

Secondly, the ability to predict a failure can lead to better resource management. It has been noted countless times that preventative maintenance is better than reactive maintenance. If an important system were to encounter a failure and the effects of such a failure can be mitigated, this will result in an overall healthier and more productive system. The downtime of the system during the failure will be less and even none in some cases, as well as the net reliability of the system would have increased. This type of information is heavily utilized in energy storage devices (batteries and capacitors). Complex electrical systems such as an aircraft commonly have complex power systems, this leads to great difficulty in assessing the overall health of the system.

Respectfully submitted,

Jason Renwick (Mr.)
September 30, 2015