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KSC Intern

Narrative Report

There are limited resources on extraterrestrial bodies and current launch vehicles can only send finite resources on deep space missions. Transporting resources needed for deep space missions is extremely expensive; at tens of thousands of dollars per pound launched. In order to sustain life and establish outposts on other celestial bodies, it is necessary to find a way to utilize the resources that are readily available in these environments. This process is called In Situ Resource Utilization (ISRU), which is comprised of searching for, collecting, processing, and storing materials found on other celestial bodies and using them for construction, science applications, propulsion, and other life sustaining purposes. The processing and use of regolith, which is a loose rocky material found on the surface of bodies like the Moon or Mars, is the main focus of ISRU work done in Swamp Works in the Engineering Development Lab at Kennedy Space Center (KSC). The research Swamp Works has done in regolith applications ranges from construction and infrastructure to propellant production to storage of oxygen and water.

Swamp Works has developed an excavation robot, Regolith Advanced Surface Systems Operations Robot (RASSOR) that specializes in excavating, storing, and dumping regolith from the lunar surface. RASSOR has a novel set of digging and collecting tools known as bucket drums. These drums are designed to dig and store regolith simultaneously, as well as cancel the reaction forces caused by digging by rotating the bucket drums in opposing directions. RASSOR is an important tool for ISRU regolith operations because it is capable of collecting more than it weighs which is vital because copious amounts of regolith are needed for any regolith application. Swamp Works has also developed Mini-RASSOR, a scaled version of RASSOR used for demonstrations and in-lab testing. Swamp Works has used a weight offloading system to test each of the robots' ability to traverse and dig while being rendered "lighter" in weight to simulate the reduced gravity of the moon. However, there is no in-lab technology that would allow for the testing of regolith behavior in reduced gravity.

Dr. Addie Dove, is an assistant professor of physics at the University of Central Florida (UCF), invited Swamp Works to participate in a reduced gravity simulation. There are various means of creating reduced gravity environments such as active response gravity offloading systems, and enhanced zero-gravity locomotion simulators, but this simulation took place on a reduced gravity aircraft. These aircraft are designed for parabolic flight experiments, in which the pilot will fly in a sequence of parabolas that create a weightless environment; at different times during the parabola, the contents of the aircraft are in free fall which causes the aircraft not to exert any ground reaction force on the contents. There are microgravity and reduced gravity modes for testing under the gravitational conditions of various celestial bodies.

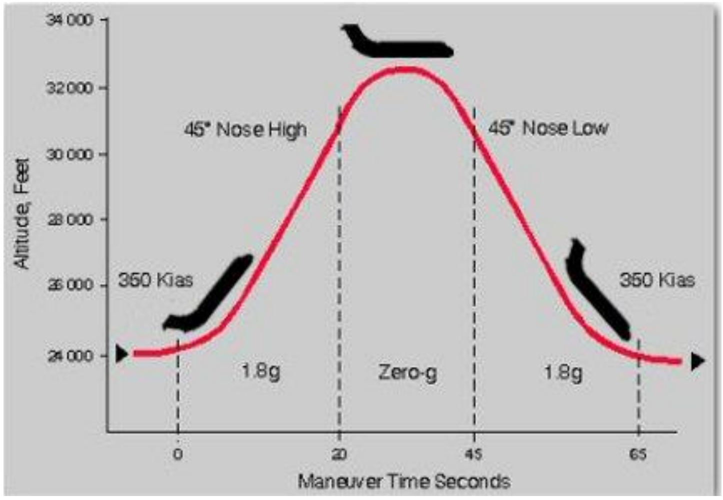

Fig 1: Course of parabolic flight (2)

This parabolic flight was an opportunity to test the flow of lunar regolith in a reduced gravity environment which had not yet been done. Lunar regolith has a tendency to bridge or collect when passing through some enclosed geometries which is why regolith flow is most important within RASSOR's bucket drums because they are charged with collecting and storing regolith within an enclosed geometry. Mini-RASSOR, as well as RASSOR, has 4 bucket drums that are separated into 4 section slices. My project was to create a scaled version of a section slice of Mini-RASSOR's bucket drums that were scaled to fit into the system used in the parabolic flight experiment. I used Creo CAD software to design and 3D printing technology to develop this hardware. At the time of this writing the experiment had not taken place and therefore there are no results of this experiment.

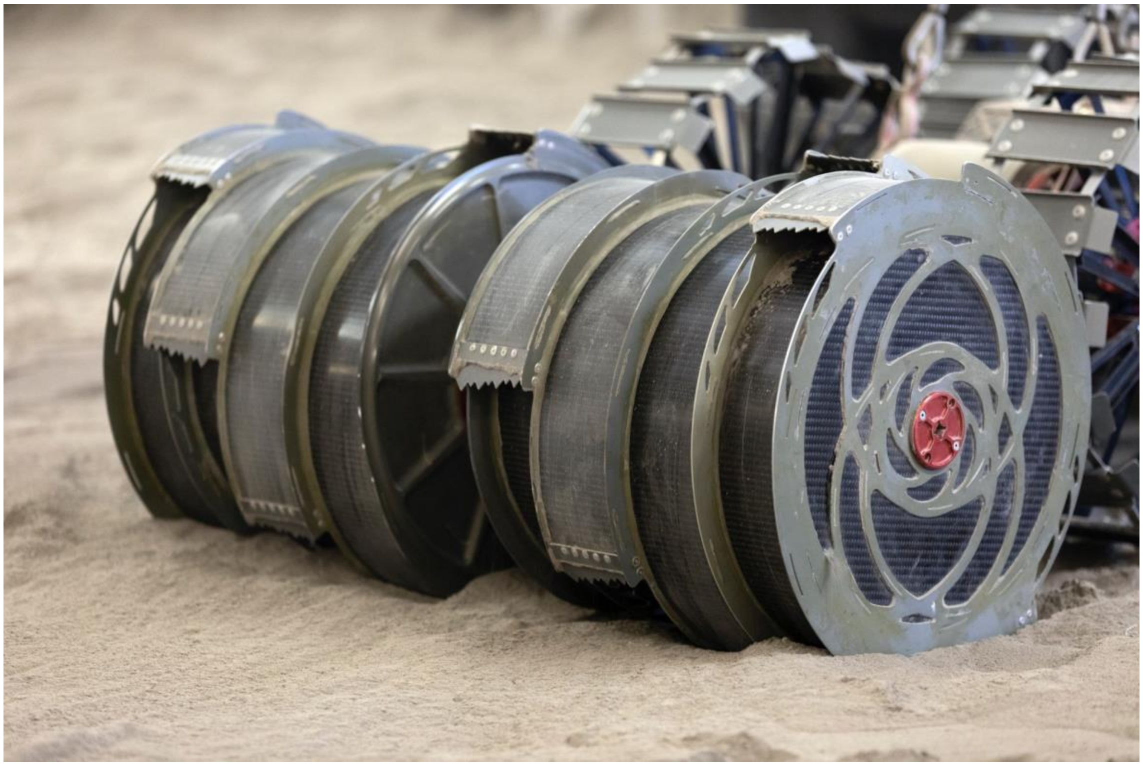

Fig 2: RASSOR bucket drums (4)

I feel as though my experience at KSC has been enriching in many different ways. I have learned a lot about myself and what I should expect from a future career. I think the most important thing I've learned is that for my career I'd like to work somewhere that allows me the creative freedom that I experienced at KSC. I always felt as if there were no limits to the ways that I could solve a problem and I was always encouraged to use as many available resources as possible to complete a task. Working at KSC has also taught me that central Florida may not be my preferred location of residence which is very difficult for me because I would like very much to work for KSC when I graduate this upcoming school year. My experience has allowed me to further evaluate what matters the most to me when picking a career path.

Appendices

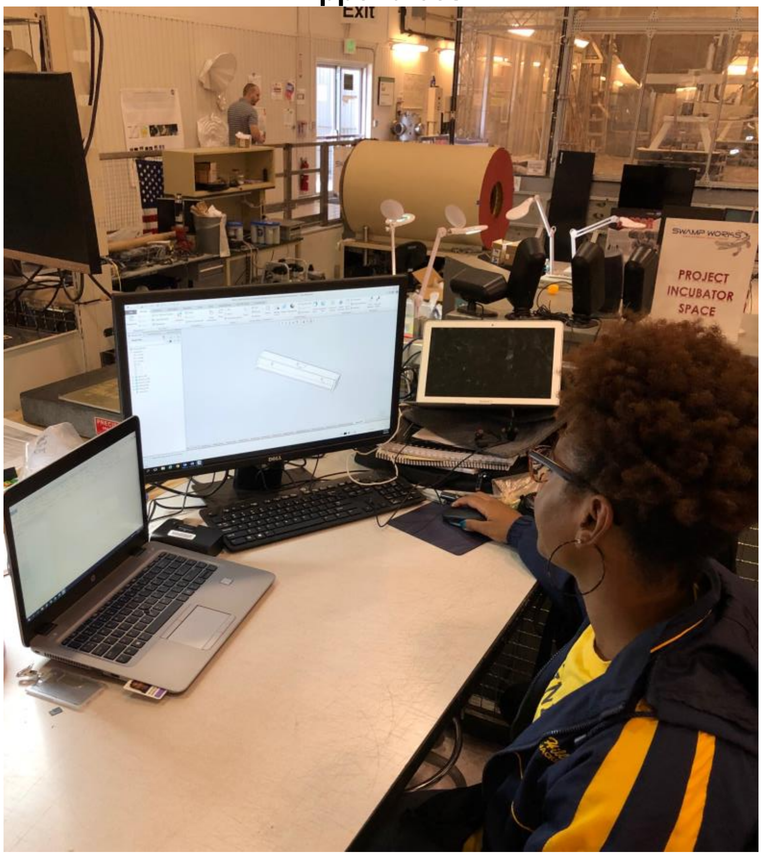

Fig 3: A major component of the project that I participated in involved iterative CAD modeling. (5)

Fig 4: Another component of my project was rapid prototyping using 3D printing technologies. (5)

References

(1) Mahoney, E. (2017, January 23). In-Situ Resource Utilization. Retrieved July 22, 2019, from https://www.nasa.gov/isru

(2) *Flight trajectory for a typical zero gravity flight maneuver* [Photograph found in NASA Reduced Gravity Research Program]. (2009, March 17). Retrieved July 23, 2019, from https://en.wikipedia.org/wiki/Reduced-gravity_aircraft#/media/File:Zero_gravity_flight_trajectory_C9-565.jpg

(3) Kennedy Space Center Swamp Works – Developing New Tools for Deep Space Exploration. (n.d.). Retrieved July 22, 2019, from https://technology-ksc.ndc.nasa.gov/featurestory/swampworks

(4) *KSC-20190605-PH_KLS02 _0051*[Photograph found in NASA Kennedy Flickr, Florida]. (2019, June 05). Retrieved July 23, 2019, from https://www.flickr.com/photos/nasakennedy/48045320012/in/photolist-dRdBdd-mbiNRX-Mpn9QL-mbjA5a-fv7roR-LTXsLa-mbiN1D-EkWuM4-U3Bfk7-2fRVSAz-2gcATRj-2gcACPr-2gcArxg-2gcAQPc-2gcAPLq-2gcAyHv-2gcAxNK-2gcAwW4-2gcAkW6-2gcAKHa-2gcAjJS

(5) Personal photographs from a personal device