

Henry Clay Summer Internship Final Report of Work

Executive Summary

As part of the Henry Clay Summer Internship program with the NASA Office of the Chief Scientist, I was able to take a leading role in developing technical reports, presentations, and communiques in the areas of additive manufacturing, extraterrestrial critical mineral resources and usages, pharmaceutical/medicinal developments for long-haul space missions, and space exploration economics in regards to their roles in developing a sustainable space exploration program in-line with the objectives of the Artemis Program. The work I performed in these areas were incorporated into two formal presentations given by Dr. Jim Green, NASA Chief Scientist, to the USGS in June and the American Chemical Society in August. Work was also used in the formulation of a white paper on lunar sustainability being submitted by NASA-OCS, scheduled for delivery in mid-September, as well as two journal articles with the intention of publication this fall.

Internship Objectives

The primary objectives of the internship were to research and outline the programs and directives NASA is pursuing as part of the Artemis Program to reestablish human presence on the lunar surface and promote long-term deep space exploration missions to Mars and beyond and support the Office of Chief Scientist in communicating these directives and mission statements across the agency and to the science community. This included being responsible for researching and drafting sections of written documents and presentations in my fields of interest. Too, I was tasked with being a liaison between the Office of Chief Scientist and three organizations: the Lunar Surface Innovation Consortium (LSIC), the Center for the Utilization of Biological Engineering in Space (CUBES), and the US Geological Survey (USGS).

Accomplishments

As part of my work to support the Office of Chief Scientist, I used my engineering experiences in environmental, pharmaceutical, and mineral processing research to take the lead on outlining the direction NASA is taking to promote sustainable space exploration in these fields. The first half of the summer I devoted primarily to exploring the additive manufacturing research NASA and partners are involved in to build habitats, research equipment, and life-sustaining devices while mitigating waste and overall material usage. Through my work, it became apparent that many reviews of space-related AM were Eurocentric, and as a means of providing an overview of US endeavors in this area to the world, I have completed an initial draft of a journal article compiling this research and Dr. Green and I intend to publish in *Room* by late fall of this year. Thus far, Dr. Green and I have been able to share, informally, some of this information through talks on the social media platform *Clubhouse*.

For the latter half of the internship, I focused on laying the groundwork for communicating NASA directives in lunar sustainability efforts specifically in relation to pharmaceuticals, critical minerals, and economics. This work has been compiled and will be used in its respective sections as part of the white paper on lunar sustainability OCS will be submitting

in mid-September and which will likely be published in a journal later this fall. Research into critical mineral resources and usages in space will also be drafted into a journal article for publication later this year.

Highlights of the Internship



Clockwise, from top left: Shaking hands with the Apollo-style spacesuit, NASA HQ; Dinner at Old Ebbitt Grill with Rhianna Clemons (left) and Dr. Neysa Call (middle), Washington, D.C.; Chatting with Fmr. Astronaut and current Vice President of Boeing Florida's operations at Kennedy Space Center Commander Bruce Melnick, Orlando, FL; Saying goodbye to LaVerne Drayton, Executive Assistant in Office of the Chief Scientist, NASA HQ; Personal tour of Smithsonian National Air and Space Museum with Dr. Jim Green, Washington, D.C.

Within 30 minutes of the initial meeting that first day, I knew who I was working with, what my projects would be, and why I would be working on them. I was able to hit the ground running and was granted independence and responsibility with my work. As such, working with the team in the Office of Chief Scientist was a remarkable experience, as a whole. I was able to produce a large volume of meaningful work and was not hindered by any trivial assignments. Being included from the onset in nearly all meetings allowed me to interact with program directors and specialists across all NASA centers and many outside organizations. My network has expanded significantly, and it has added breadth since many of my interactions were with

those outside of my field of chemical engineering. Specifically, I greatly enjoyed working with the US Geological Survey Outreach Coordinator Mike Jarvis planning and drafting a presentation given by Dr. Jim Green on the mineralogy of Mars to a joint NASA-USGS session, especially since I had spent the year preceding the internship researching rare earth metals and rare earth extraction processes. The work I completed regarding the use of pharmaceuticals and medicinal practices during long-haul space missions was also a highlight, as not only did it allow me to discover and present the cutting-edge research NASA and affiliates are involved in, but also get a chance to talk to those working in the research field I would like to pursue upon completing my Ph.D. in chemical engineering.

Above all, though, the highlight of the internship is that I feel I have made lifelong mentors and friends out of the people I worked with at NASA. Dr. Neysa Call came to Kentucky the second to last week of the internship and us two interns were able to work together with her for a week in person. I even managed to take her and Rhianna Clemons to my old workplace, the Rare Earth Element Pilot Plant in Providence, KY, for a tour. Then, of course, this past week both Rhianna and I were able to make the trek to Washington, D.C., and meet Dr. Call, Dr. Green, Dr. Tara Ruttley, and Mrs. LaVerne Drayton for two full days, sharing several meals, laughs, unbelievable stories, and even a personalized tour of the Smithsonian National Air and Space Museum by the one and only Dr. Green. All the stops were pulled for us, and it was an unforgettable trip!

Recommendations for Future Interns

It is my sincere hope that by this time next year, the internship experience will be able to be held in-person at NASA Headquarters. Inasmuch, I expect the ten-week program to look very different from my own experiences. However, I can say that it is imperative to take full advantage of the opportunities that lie before you at the start of the internship. Introduce yourself to all, go to as many of the seminars as you can, chat with the presenters, email those follow-up questions, and stay invested throughout the ten weeks. There is only so much that can be done in a ten-week span, no matter how immersive or intensive the internship. The impressions and connections you make will be what will extend well beyond your final day, and I can assure you that these connections will be important to have when starting your budding careers, both professionally and personally.