AURORA

From Kodiak to the moon: Student Kahryn Buchanan's equations help future lunar missions

By Sam Bishop

Above: Kahryn Buchanan works on her laptop in the Engineering Learning and Innovation Facility's Usibelli Coal Mine Student Atrium in early 2020. UAF photo by JR Ancheta.

UAF student Kahryn Buchanan was back with her family on Kodiak Island this past spring, sent home by the coronavirus closure, when someone at NASA shot her an email.

The space agency wanted to know if she could she do a phone interview for a summer internship to which she had applied months before.

Buchanan didn't get the email right away.

She was out camping. No service. The message didn't load on her phone until she came back into signal range.

"As I got service, I got the email," Buchanan recalled in a November interview. "It had 'NASA' in the subject line, so I started freaking out."'

Buchanan, an 18-year-old now in her second year at UAF, got the interview and got the internship — despite being incommunicado when NASA first reached out.

Curiously, her work could help prevent that very problem for future astronauts on the moon.

During the internship, Buchanan created equations to simulate factors that could interfere with radio signals between a lunar ground station and an orbiting command module.

It was just her kind of work. At UAF, Buchanan is pursuing degrees in mechanical engineering, computer science and math. She took her first college-level math class at age 13. By the time she graduated from high school, she'd also earned an associate degree from Kodiak College.

“Math can be rough, but I love the feeling of solving an equation, and realizing I understand, from the back, what’s going on and I can replicate this as much as I want to,” she said during an interview in February 2020.

A summer at home

Shortly after that interview, campus closed and classes went online. Buchanan returned to Kodiak.

After securing the internship this spring, Buchanan wasn’t able to travel to NASA’s Glenn Research Center in Cleveland, Ohio, where she was originally to be based. Instead, she worked online all summer from home in Kodiak. Then, after the fall 2020 semester began, she worked another month from her room in the Cutler Apartment Complex on the Fairbanks campus.

Kahryn Buchanan works on her NASA-supplied laptop while at home in Kodiak in summer 2020. Photo courtesy of NASA.

The internship was full-time, paid work, done on top of her full class load.

“It’s definitely been one of the toughest semesters I’ve had, but I think that’s how a lot of people are feeling this year,” she said. “I felt like I was behind from the very beginning, but things have worked out. I’m getting through it just like everybody else and working hard, and that’s all you can do.”

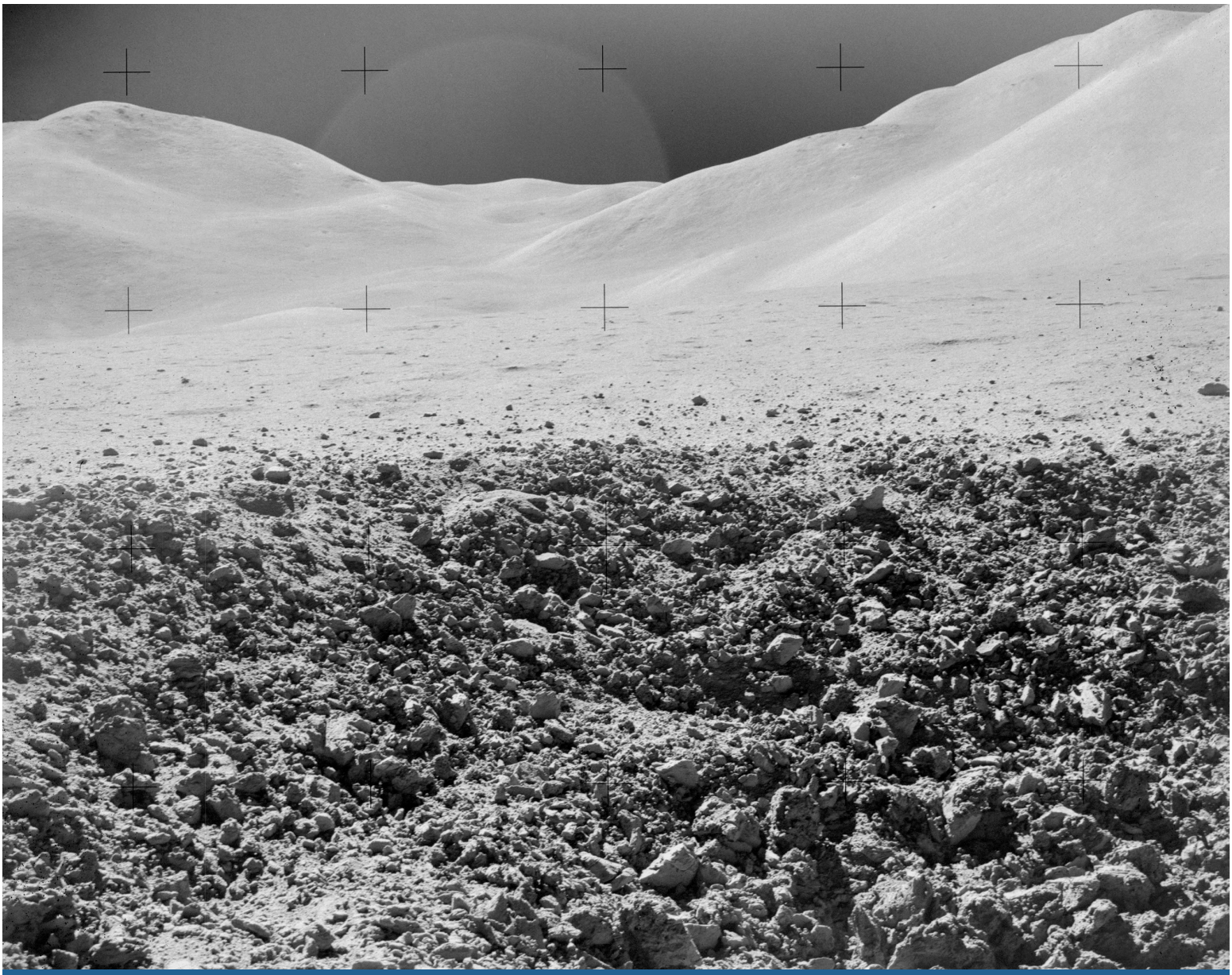


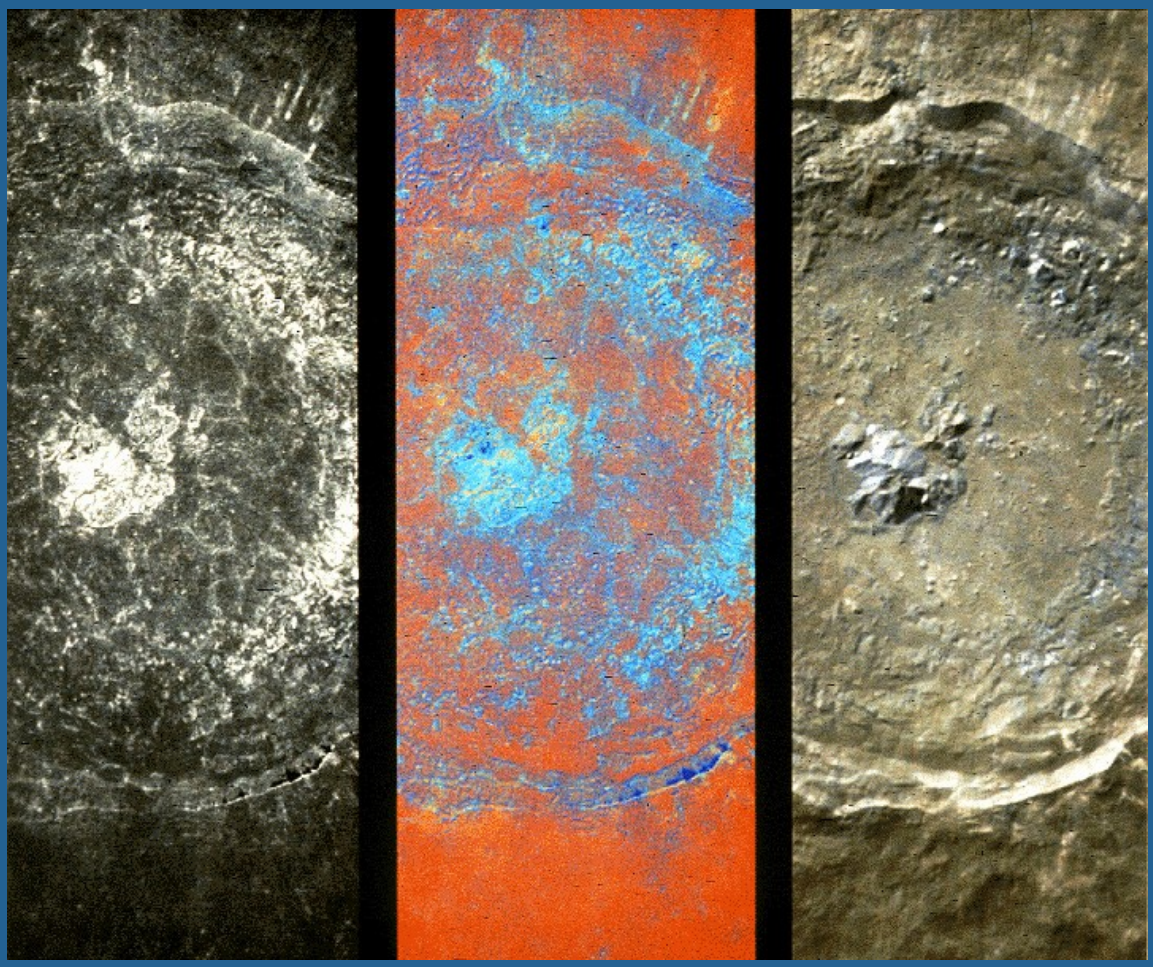
Image caption: The surface of an unnamed lunar crater is strewn with rubble on Aug. 2, 1971. David Scott and James Irwin, two of four astronauts on the Apollo 15 mission, captured the image while exploring the Mons Hadley Delta region. Image courtesy of NASA.

Returning to the moon

With NASA, Buchanan was on a team of three interns. The others were in California and Ohio.

NASA sent them each a laptop. Their task was to help understand something called “multipath interference” in radio communication between a lunar orbiter and a ground station.

“Multipath interference specifically refers to the phenomenon when part of your signal bounces off something in the environment and bounces back to the receiver,” Buchanan explained. “So you’re receiving two of the same signal, but they’re sort of staggered. So that causes interference.”



Three images from the Clementine spacecraft’s ultraviolet and visible light camera portray the moon’s 63-mile-wide Tycho crater and its central peak on Feb. 28, 1994. The pictures were produced with different filter combinations to reveal surface material types. Images courtesy of NASA.

NASA needs to know how that interference affects communication, said Peter Schemmel, an electronics engineer at the Glenn Research Center who served as the team's mentor.

"NASA has big plans to return to the moon in 2024 and beyond, and multipath interference is a problem that we're trying to understand and minimize," he said.

Photo caption: Peter Schemmel. Photo courtesy of NASA.

Schemmel earned his doctorate in astrophysics at England's University of Manchester, where the famed geophysicist Sydney Chapman '58H (H denotes honorary degree) completed his studies decades before coming to the University of Alaska in 1953. Schemmel himself visited Fairbanks a few years ago to install one of NASA's atmospheric propagation terminals on top of the Elvey Building. The instrument tracks changes in satellite signals caused by weather, useful when designing systems.

In NASA's upcoming lunar missions, Schemmel said, maintaining communication with astronauts on the moon

will be complicated.

“It’s going to be a little bit different from the Apollo days — two guys on the moon in a very localized space,” he said, referring to the series of NASA missions that landed astronauts between 1969 and 1972. “There’s plans to stay on the moon longer, do more science, look for water ice.”

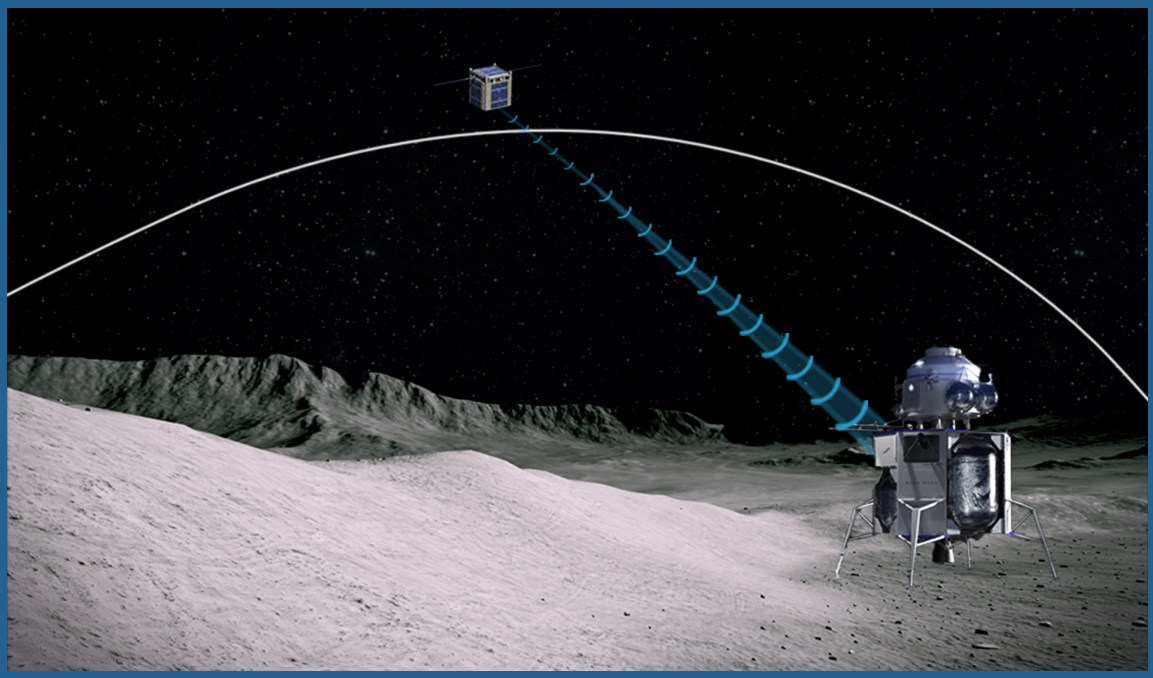
Image caption: The Apollo 8 crew, the first to orbit the moon, captured this image of the far side of the moon in December 1968. Image courtesy of NASA.

Simulating interference

To explore the problem of multipath interference, Buchanan's intern team used a computerized simulator called the Multiple Asset Testbed for Research in Innovative Communication Systems, or MATRICS. It

feeds information to the same communications hardware that would be used in a moon mission, Schemmel said.

“This testbed tricks that hardware into thinking it’s actually flying around the moon,” Schemmel said.



A cube satellite communicates with a lunar lander in this NASA visualization. UAF student Kahryn Buchanan wrote equations to model such a system in summer 2020 as a NASA intern. Her equations were used in the Multiple Asset Testbed for Research in Innovative Communication Systems, a project based at NASA’s Glenn Research Center in Cleveland, Ohio. Image by NASA Space Communications and Navigation.

Buchanan said her team specifically looked at what sort of interference might occur if one piece of the hardware — an antenna on the orbiter — got stuck in the wrong position.

“There have been a couple times in history where those antennas have malfunctioned,” she said. “It was important for us to explore the mechanics of that and how we might get around that.”

Another intern on the team, Claire Harding, researched the hardware — the kinds of antenna that could be used.

Meanwhile, Buchanan wrote the equations that the testbed could use to determine the positions of the hardware at any given moment.

“First I had to come up with the orbital position equation that describes the location of the lunar command module at any point in time,” she said. “From that I was able to derive the distance equation for the distance between the transmitter and the receiver at any time during orbit. And from that I was able to get the equation for the antenna angles, both the angle of the antenna coming off the lunar command module and the angle of the antenna receiving on the moon.”

A third intern, Nathan Dixon, put the equations into the testbed using Python computer programming language.

“(That) allowed us to have multiple things that were iterating at all times,” Buchanan said. “So we had like basically loops inside of loops inside of loops going

through all these data points calculating the angles at each point."

"I remember at the end, when we had all of our equations in one script, the script took about 20 minutes to run," she said. "And, you know, Python is pretty fast. Usually it's instantaneous."

A successful project

The results were thousands upon thousands of data points that can define the expected multipath interference in any given lunar orbiter position.

"They were able to put together all the pieces, from initial theoretical equations all the way to actually simulating communication channel characteristics like data rate and throughput, things of that nature," said Schemmel, the team's mentor. "So it was a full end-to-end performance."

Kahryn Buchanan talks online with astronaut Doug Wheelock during her summer 2020 NASA internship. Photo courtesy of NASA.

Buchanan hopes to return to the NASA internship in 2021. With any luck, she won't be working in Kodiak.

Not that she disliked being home this past summer, especially because it was an unusually sunny season. But the island's dominant occupation and preoccupation doesn't appeal to her.

"I'm not a big fan of fish," she said.