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## **Science**

## It Started as Winter Break. It Ended With a Doomed Moon Mission.

Carnegie Mellon University students built Iris, a tiny lunar rover. When the spacecraft carrying it to the moon malfunctioned, they turned their vacation house into mission control.

## **By KENNETH CHANG**

gaggle of students from Carnegie Mellon University in Pittsburgh traveled to Florida last month during their winter break.

The students, many of them studying to be engineers and scientists, went there to watch a rocket launch that would send a small 4.8-pound robotic rover that they had helped build on its journey to the moon. Afterward, they hoped to have time for some sun and fun, renting a large house just three blocks from the beach.

Their trip did not go as planned.

"We never saw the beach," said Nikolai Stefanov, a senior studying physics and computer science.

The rover, named Iris, headed toward the moon on schedule in a perfect inaugural flight of Vulcan, a brand-new rocket. But the spacecraft carrying the rover malfunctioned soon after launch, and the students turned their rental house into a makeshift mission control as they improvised how to get the most out of the rover's doomed journey.

"We had a mission," said Connor Colombo, the chief engineer for Iris. "It wasn't the mission we thought. And in fact, maybe that made it more interesting because we had to do a lot of thinking on our feet, and I'm really grateful to have had that."

The Vulcan rocket, built by United Launch Alliance, lifted off on Jan 8. Aboard this rocket was Peregrine, a commercial lunar lander built by Astrobotic Technology of Pittsburgh. It was the first American spacecraft



PHOTO COURTESY OF CARNEGIE MELLON UNIVERSITY

Madhav Gajula, left, a student in the Mellon College of Science, and Nikolai Stefanov, the mission operations lead for Iris, work during a mission simulation.

launched in more than 50 years with the aim of gently setting down on the surface of the moon.

And aboard Peregrine was Iris, about the size of a shoe box and designed and built by the Carnegie Mellon students. It was one of the payloads on this robotic mission; Astrobotic's main customer was NASA, which was sending several experiments as part of the preparations for sending astronauts back to the moon in the coming years. For the students, the trip to Florida was supposed to be an entertaining lull during winter break to celebrate that Iris, after years of effort and waiting, was finally heading into space.

"We had filled our itinerary for the trip with other fun things," said Carmyn Talento, a senior who served as the representation team lead for the Iris mission.

Iris started in 2018 as an undergraduate class of Red Whittaker, a professor of robotics at Carnegie Mellon. He gave the students an assignment: Put a tiny rover on the moon.

Dr. Whittaker was one of the founders of Astrobotic a decade earlier as a competitor in the Google Lunar X Prize, which offered \$20 million for the first privately financed venture to put a spacecraft on the moon. None of the competitors even got to the launchpad before the competition ended in 2018.

Astrobotic is now one of several companies that believe there will be profits in providing a delivery service to the moon. (Another of those companies, Intuitive Machines of Houston, is aiming to launch its spacecraft to the moon next week.) Dr. Whittaker saw that these commercial ventures offered the possibility of cheap lunar missions like the one he asked his students to come up with.

Although Dr. Whittaker is no longer directly involved with Astrobotic, he talked with company officials about the size, weight and constraints of what could fit on Peregrine. That made the rover a real-life engineering problem for his class.

"I actually knew the height above the ground for the attachment and hence the release and how far it would have to float to the ground," Dr. Whittaker said. "And so it would be possible to compute the energy of impact and the dynamics that would relate to either landing in a stable position or tipping if it hit the wrong rock."

Successive classes of students devised and revised the design, then built and tested the rover. Other students also joined in, training to work in mission control or taking on other tasks.

After a succession of delays, the Vulcan rocket finally made it to the launchpad in January.

Some of the Carnegie Mellon students flew to Florida. Others traveled via van, driving nearly 1,000 miles south from Pittsburgh. Some former students who had worked on the rover and since graduated also made the pilgrimage. (Mr. Colombo, the chief engineer, graduated in 2021 and now works at Astrobotic.)

They were set to stay in the vacation house for four days in case the launch was delayed by bad weather or technical glitches.

The difficult, pressure-filled part of their mission — turning the rover on, deploying it onto the surface and driving it around before the battery energy drained dead in two to three days — should have still been in the future, after Peregrine landed on Feb. 23



PHOTOS COURTESY OF CARNEGIE MELLON UNIVERSITY

In a clean room at Astrobotic Technology in Pittsburgh, a small, four-wheeled rover named Iris was attached to the Peregrine lunar lander.



An earlier model of the Iris Rover during a demonstration in April 2023.

on the near side of the moon in a spot known as Sinus Viscositatis, or Bay of Stickiness.

By then, winter break would be over, and they would be back at Carnegie Mellon, juggling their spring classes with stints in a mission control facility that the university constructed for this and future space missions.

The Vulcan rocket lifted off without incident. Less than an hour later, Peregrine separated from the rocket's upper stage, on its way to the moon.

But soon after, Astrobotic announced on X that "an anomaly occurred." Later in the day, the company said, "We are currently assessing what alternative mission profiles may be feasible at this time."

Astrobotic's engineers believe that a faulty valve failed to fully close, leading to the rupture of one of the spacecraft's tanks. With propellant leaking into space, the possibility that Peregrine could land on the moon was gone.

"Then the question became, 'OK, what can we do now?" said Mr. Stefanov, who was leading mission control for the rover. "We weren't worried at all. I think in some ways we were excited."

In the rental house, "We split up, kind of sectioned off parts of the house to designate to certain things," Mx. Talento said. "We had a table in the living room that was kind of our main place of operations where we had several laptops, and we moved a TV from another room to be another monitor. That was kind of the main mission control room."

Up to 30 people were in the house, Mx. Talento said.

For security reasons, the people in Florida could not directly tap into the spacecraft systems over the internet. Instead, a skeleton crew at Carnegie Mellon served as a go-between, conveying messages between the Peregrine spacecraft managers at Astrobotic's Pittsburgh headquarters and the beach house.

"Somehow it worked," Mr. Colombo said.

Several days into the mission, Astrobotic started providing power to the payloads like Iris. Raewyn Duvall, a graduate student in electrical and computer engineering who served as the program manager for Iris, remembers watching the video monitor when telemetry started arriving from the rover. "They hadn't told us they were turning us on at that moment, so it was an unexpected heartbeat," Ms. Duvall said.

The Iris team then started turning on systems on the rover like the computer and two-way communications that were originally not planned to be turned on until after arrival on the moon.

When the beach house rental ended, the students headed back to Pittsburgh for the remainder of the mission. And then on Jan. 18, it was over.

Peregrine's trajectory was designed to swing around Earth once before heading back out to rendezvous with the moon. But the propellant leak had nudged the spacecraft onto a collision course with Earth. Because of the damaged condition of the propulsion system, NASA convinced Astrobotic that the best approach was to just let Peregrine re-enter the atmosphere and burn up.

There will not be another Iris, but there will be other lunar missions built with contributions by Carnegie Mellon students. One is MoonRanger, a rover that is a bit bigger, about the size of a suitcase and weighing seven pounds. It will look for signs of water near the moon's south pole.

And this spring there is another space robotics course at Carnegie Mellon. "So we know there's a class of people working on the next ones," Ms. Duvall said.

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