Student-designed rover can go to extremes [1]

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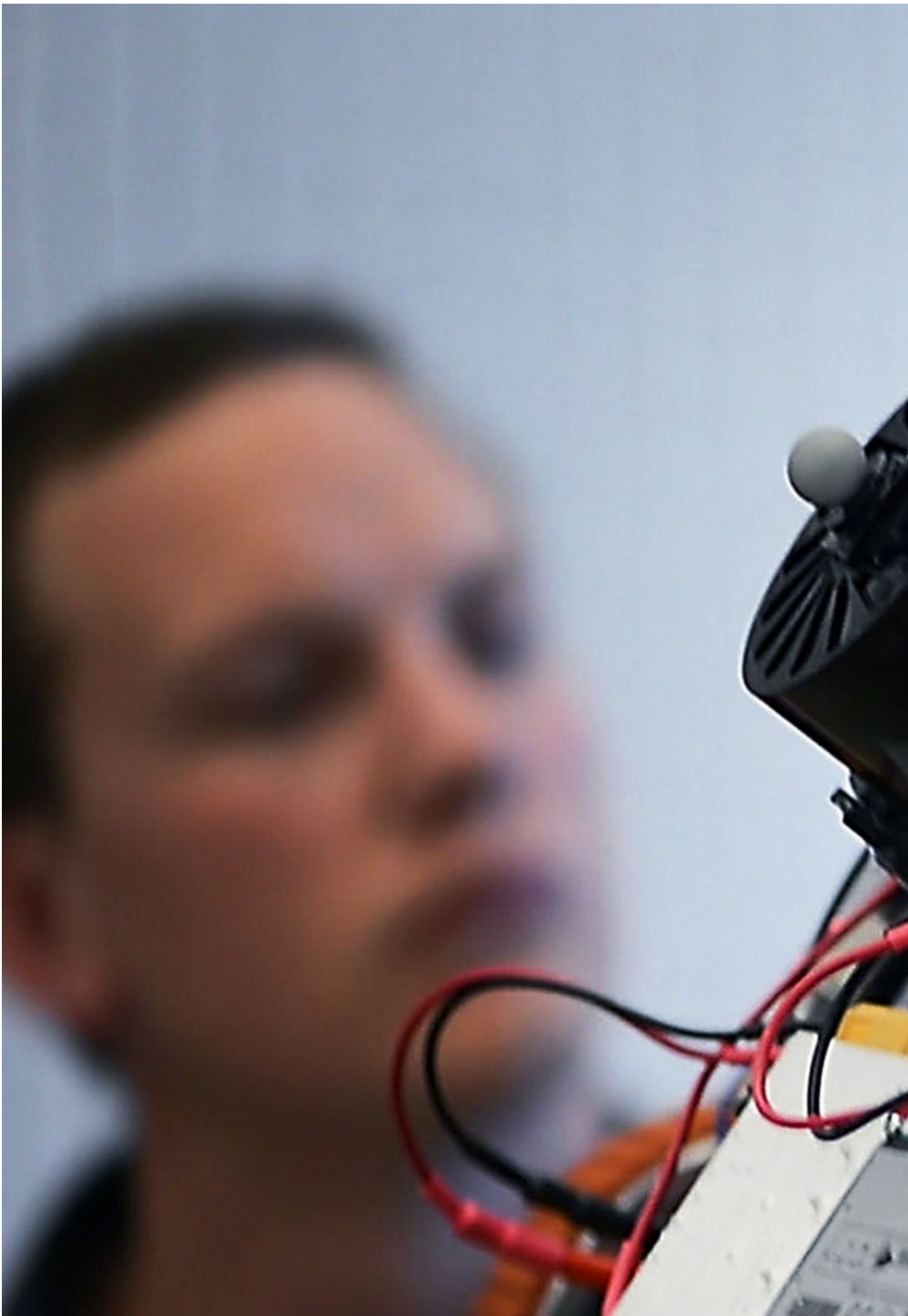

Just before midnight Saturday, one day before the final presentation, the project came to a dead stop.

The following Monday, the student aerospace engineering team was scheduled to perform a live test of their prototype land exploration rover to a high-profile client. But the microcontroller—the circuit board that commands the rover—was fried.

The team's capstone project, a Descending/Ascending Rover for Exploration (DARE), is one of 10 practicum design projects for undergraduate seniors in the Department of Aerospace Engineering Sciences [2]. Over two semesters, students design, build and test a system for an industry customer.

The DARE team's client was NASA's Jet Propulsion Laboratory [3] (JPL), the nation's leading center for robotic space and earth exploration.

Over the past six years, JPL has partnered with CU's aerospace senior design projects by requisitioning a family of rovers. Previous teams have developed a mother rover, which is a communication hub and docking station for child rovers that collect data from the terrestrial surface. Each new team builds on previous designs.

This year JPL asked the student team to create a child rover that could navigate 20-30 feet of rough terrain and climb steep slopes up to 70 degrees, with the goal of collecting data in canyons and volcanic craters.

Researchers have developed varying mechanisms for climbing rovers, such as vacuum systems, rock-crawling robots, and machines with microfiber grippers, but many of them are inefficient or expensive. The DARE team adopted a suction fan design that operates like a reverse hovercraft.

"We liked the idea because very few people have done it, and it was affordable," said Chis Bennett, the team project manager.

The DARE vehicle consists of a platform with an imbedded fan that pulls air from enfolded space under the platform, called a control volume. The control volume is surrounded by a rubber skirt that sits close to the ground. When the vehicle is set on a slope, the fan creates a pressure differential where airflow inside control volume is at equilibrium, effectively holding the rover to the surface. The camera on the rover collects data to share with the mother rover via Wi-Fi.

The team tested the rover's climbing ability on long plywood boards placed at 30, 50 and 70 degree inclines. The boards were covered with polyurethane and sand, to replicate a sandstone surface similar to one the rover might encounter on a canyon wall.

"I really enjoyed the hands-on aspects of the project," Bennett said. "We were able to get out of the kind of theoretical hard math and science classes and really apply what we had learned over the last four years."

Serving as the primary liaison to the customer, Bennett had his first taste of requirements development—an industry term that involves optimizing a design, process or product to be

valuable to the customer. With assistance from his team and academic advisor, Bennett worked to align the project with JPL's requirements that the results be verifiable, complete, independent and relevant.

"It was simultaneously very challenging and a great learning experience," he said. "Being able to say I know how to drive requirements is extremely valuable."

Like situations the students might face in a professional environment, things don't always go as planned. The weekend before their final presentation to JPL, the rover's onboard microcontroller failed due to a circuitry protection error. The tiny electronic device controls all of the rover's systems including the suction fan, navigation, communication and data collection.

"We got to practice that troubleshooting process," Bennett said, explaining that gathering opinions from the customer, teammates and their advisor is vital to overcoming obstacles. "That is something that happens all the time in engineering."

Instead of giving up on fulfilling their customer's order, the team devised a manual solution—an external switchboard that could control the rover's movements.

Bennett recalled running to the Engineering Center late that night with his seven teammates, pulling several feet of wiring from spools in the control shop, digging through bins for scrap switches and circuit boards, soldering wires and piecing together the manual controller.

In the end, the team delivered a successful product to JPL.

"It was a very frantic there for a few hours," he said. "But it worked and we were able to prove our design."

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