Scientists simulate effects of blowing Mars dust

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Gusting winds and the pulsating exhaust plumes from the Phoenix spacecraft's landing engines could complicate NASA's efforts to sample frozen soil from the surface of Mars, according to University of Michigan atmospheric scientist Nilton Renno.

Set to launch Aug. 3 from Florida, the $414 million Phoenix Mars Lander will use descent engines to touch down on the northern plains, where vast stores of ice have been detected just below the surface. A robotic arm will scoop frozen soil and dump it into science instruments that will analyze its chemical content to see if it has the potential to sustain microbial life.

With funding from NASA and the spacecraft's manufacturer, Lockheed Martin, Renno and his students are conducting a series of experiments to determine how much dust the 12 descent engines will kick up and whether martian winds could interfere with efforts to deliver soil to the onboard mini-lab.

Renno, an associate professor in the College of Engineering's Department of Atmospheric, Oceanic and Space Sciences, is a member of the Phoenix science team.

"I proposed that my engineering students look into some of the challenges that the Phoenix team will face when the spacecraft arrives at Mars," Renno said. "I wanted the students to contribute to the success of the mission in a meaningful way."

In a laboratory at the U-M Space Research Building, his team built a Phoenix thruster test chamber that looks a bit like a Plexiglas shower stall. But instead of a shower head, the enclosure is fitted with a high-pressure gas nozzle pointing down at a floor covered with 5 inches of reddish sawdust. The pungent wood dust simulates Mars soil, and the nozzle represents one of the 12 Phoenix landing thrusters.

Instead of liquid rocket fuel, the U-M researchers use nitrogen gas at pressures up to 400 pounds per square inch. They fire short bursts into the soil to mimic the pulsating Phoenix landing engines, filling the lab with dust and a loud, staccato blast like machine-gun fire.

Renno's team will repeat the thruster experiment in Ann Arbor a few more times before dismantling the apparatus and taking it to NASA's Ames Research Center at Moffett Field, Calif., for July tests inside a large vacuum chamber that more closely simulates Mars conditions. In the California tests, crushed walnut shells will be used to mimic the behavior of soil on Mars, where the surface gravity is 38 percent of Earth's gravity.

Renno and U-M doctoral candidate Manish Mehta said there are several concerns about the Phoenix thrusters. They said the supersonic exhaust jets could: buffet the spindly, three-legged probe during the critical final seconds before landing; scour the landing site and strip it of loose soil; and possibly contaminate the martian soil with hydrazine, the liquid fuel used in the thrusters.

"These experiments are mainly run to provide insight to the Phoenix team, so they know what to expect and can somewhat prepare for it," said Mehta, who will use the results in his doctoral dissertation. U-M aerospace engineering senior Neal Rusche and other students from Renno's Multidisciplinary Engineering Design course also are on the team.

Another set of Phoenix experiments underway in Renno's lab examines the 8-foot robotic arm's ability to deliver soil samples from its scoop into onboard science instruments.

Mission engineers had planned to dump soil samples into the mini-lab intakes from a height of 10 centimeters, about 4 inches. Renno said winds of up to 11 mph are expected much of the time at the Phoenix landing site during the three-month main mission, which begins with arrival on May 25, 2008.

"We calculated that if you deploy the soil 10 centimeters above the instrument intake, most of the particles will be blown away and will not fall inside the instrument," Renno said. "So now we want to test that in the lab to see if the calculations are really true."

In coming weeks, Renno and his students will release wood grains of various densities inside a small U-M wind tunnel and photograph the blowing particles with a high-speed camera. Ebony, bamboo and balsa will be used to represent ice, soil and dust.

If the tests show that even relatively weak winds could hinder Phoenix sample delivery, one option is to move the scoop closer before dumping. But that also increases the risk that the robotic arm might strike the spacecraft.

"These tests are valuable in two ways," said Leslie Tamppari, Phoenix project scientist at NASA's Jet Propulsion Laboratory in Pasadena, Calif. "One is to alert us that we want to get the scoop as close as possible to deliver the samples."

Though the original plan was to dump samples from a height of 10 centimeters, it should be possible to do it safely from 3 centimeters (1.2 inches), she said.

"And if we learn that the winds pick up every day in the afternoon but are calm in the morning---as you might expect---then we would probably try to deliver the samples in the morning, so we minimize losses," Tamppari said.

Source: University of Michigan