SCIENCE & TECHNOLOGY

Robots Ready to Roll on Rocky Mars Surface

MIT students design vehicles that can climb rocks, sense hazards, and send data to Earth

By Simson L. Garfinkel
Special to The Christian Science Monitor

CAMBRIDGE, MASS.

WORKING with a shoe-string budget but with a lot of enthusiasm, students at the Massachusetts Institute of Technology (MIT) here are designing a robot they hope one day will travel to Mars.

So far the group, called the Planetary Rover Baseline Experiment (PROBE) Laboratory, has built two prototypes: MITy-1 and MITy-2. Their intended mission: to roll around the rocky surface of the fourth planet, perform experiments, and send the results back to Earth.

In building the prototypes, the 15 students who make up the lab are making discoveries that should help United States space scientists better understand the problems in sending robots to another planet.

"We're providing data that is needed for robotic exploration," says David Kang, the project's manager and a scientist at the Charles Stark Draper Laboratory, which is funding part of the project and providing laboratory space for the students through a joint program with MIT.

The MIT students are one of four groups in the US developing a robot that could explore Mars, says Charles Redmond, a spokesman for the National Aeronautics and Space Administration (NASA). Although each group is exploring a different approach, they all have the same goal: "To develop the technology and test [its] efficacy for the particular tasks which we know will be required," he says.

Those tasks include navigating around the Martian surface, avoiding obstacles, and placing scientific instruments on the ground. In the Mars mission envisioned by the MIT students, scientists on Earth would begin each day by looking at a picture of the Martian landscape from the rover's camera and choosing a target. The robot would then travel to that destination and send back measurements. Since the robots would be solar powered, they would shut down at the end of the day and "sleep" through the Martian night.

Because it takes radio waves up to 20 minutes to travel between the two planets, it is not possible to control an exploratory robot from Earth. Instead, the robot has to be able to operate autonomously – either keeping itself out of danger or extricating itself from problems when they arise.

"It has to distinguish between safe terrain and hazards," explains Bill Kaliardos, a graduate student working on the robot. "As humans, we do that almost automatically.

For example, the robot needs to be able to steer around rocks and other obstacles in its path. In many cases, it is easier to simply go over the obstacles. One of the students' early breakthroughs was developing a way to do that.

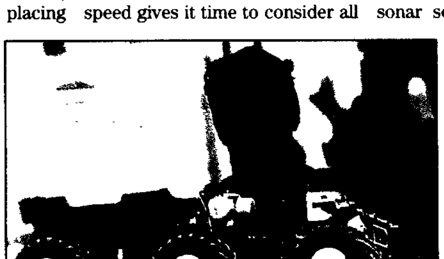
"It's a new concept – a six-wheeled, articulated frame," says Eric Malafeew, a graduate student in mechanical engineering who wrote parts of the robot's control software for his master's thesis. The segments of the robot's body are attached with flexible springs. When the robot's front wheels hit a rock, its body bends like an inchworm encountering a pebble. The design lets the rover climb objects "of its own height," Mr. Malafeew says.

Not all obstacles can simply be climbed over. Sensors mounted on the front of the robot can detect a sudden drop. The computer constantly checks each of the sensors and stops the wheels if it detects a problem. And it needs to know when to ignore the readings from the sensors – for example, when it is pointed up into the air, climbing over a rock.

"One of the big [reasons] why this whole task is possible is that [the robot] is not going that fast – just one foot per second," says Mr. Kaliardos. The robot's slow speed gives it time to consider all the potential problems in its environment.

PHOTOS BY R. NORMAN MATHENEY - STAFF

DEMONSTRATION: *Students show what their big-wheel interplanetary rover, MITy, can do at the Smithsonian Institution in Washington last summer.*



WALKING EYE: *MIT engineering student Stuart Schafer holds MITy, which can operate autonomously. Its camera will send views of the Mars landscape to Earth.*

Until now, the only photographs of the Martian surface were taken from the two Viking landers in 1976. "I've always wondered what is beyond," Dr. Kang says. "These rovers can take cameras beyond that horizon."

The students started building their first robot, MITy-1, in 1991. In addition to six wheels and its on-board computer, MITy-1 has sonar sensors to detect its distance from obstacles, a magnetic compass to determine its direction, a two-way radio system to communicate with its base station, and batteries.

The group's second robot, MITy-2, was built in 1992. MITy-2 has sensors designed to be more appropriate for the Martian environment. Since Mars has a much thinner atmosphere than Earth, a laser range finder replaces the earlier robot's sonar sensors.

Most of the graduate students working on the project are in the "Draper Fellows" program, which pays tuition and provides them with a stipend in exchange for their work on a research project. Seven undergraduates also work on the project through MIT's Undergraduate Research Opportunities Program.

"It's been a good deal. We get our own desks and phones and have lots of computer resources," Malafeew says.

Despite the funding, however, the budget is tight. Not counting labor, the students have spent less than $10,000 on each rover – virtually nothing in the high-priced world of space science. The low cost is partially a result of pursuing a "microrover" design, says Malafeew. "When you shrink it and make it lightweight ... everything gets smaller. You have to operate with much less power, less complex navigation, less sensors, and a smaller computer." All that translates to savings.

To cut costs further, the students used off-the-shelf equipment, says Kaliardos, who will receive his master's degree in June for work on the rover's sensors and hazard-avoidance systems.

Mars doesn't have a magnetic field, so instead of a compass, MITy-2 is equipped with a homemade sextant: By observing the direction of the sun and comparing it with the current time, the robot can figure out in which direction it is pointing. The students built their sextant out of the lens from a front-door peephole that they bought at a local hardware store.

Because the students can't test their robot on Mars, they've had to rely heavily on computer simulation to verify their design. "I'm trying to figure out where the center of gravity is and see at what point it will roll over," says Calvin Ma, who will earn his master's degree this May for computer work that simulates how the rover behaves when crawling over obstacles.

But more than any single technical innovation, says Kang, what's important about the project is that all the research has been done by students. In addition to meeting NASA guidelines for the weight and size of the rover, "these projects have to fulfill student thesis requirements."

Kaliardos likes working on the robots because it has given him a chance to work "hands-on" with space technology.

"A lot of this dealt with electrical engineering and avionics – the kind of thing that I didn't pick up in my undergraduate [education]. It opened up a lot of doors," he says.

NASA may send its first robot to Mars as early as 1996, says Donna Pivirotto, who heads a similar microrover project at the Jet Propulsion Laboratory (JPL) in Pasadena, Calif. The mission "is scheduled to launch in November 1996 and land on Mars in November 1997," provided that Congress approves funding.

Right now, JPL plans to send its own micro-rover to Mars on the first mission. "We only have until 1996 to get a flight rover ready to go, and MITy isn't there," she says.

Nevertheless, the MIT students are working at improving their robot's spaceworthiness. This summer, they hope to simulate part of a Martian mission with a 12-hour field test in a quarry near Boston. And at the end of next year, Kang plans to "design freeze" the robot – that is, stop changing the design, and concentrate solely on issues of durability and reliability.

"If they decide to launch the JPL rover and have a couple of kilograms left over, they could put ours on too," Kang says hopefully.