"The general feeling [in the Pentagon] is that there are lots of wealthy IT companies out there that should be funding 6.1 and 6.2 efforts"—the budgetary designations for basic and applied research—"and that neither DARPA nor even the NSF should be as involved in this as it once was," says Robert Charette, a risk management consultant based in Spotsylvania, Va.

But the NSF's Freeman says that expecting industry to step in may be wishful thinking. "Companies are rewarded in the stock market on the profits that they make this quarter," he says. "They do not get rewarded by spending money that may not lead to anything useful to them or that may take 10 years to show results." Though a few universities have always attracted some corporate funding, he adds, "when you get beyond MIT, Berkeley, Stanford, Carnegie Mellon, and a few others, there's not much industry money available."

Companies do not like to invest when results show up only 10 years later

So Patterson's lab may continue to be an anomaly. The RAD Lab will operate similarly to other privately funded projects at Berkeley: results will be reported first to sponsors at twice-a-year, three-day retreats. But the work is nonproprietary, Patterson says, adding that "like all academics, we publish like crazy in the open literature." After three years, the lab plans to review its progress to ensure things are going well. Apart from that, he expects the sponsors to take a backseat. "That's the way they wanted it. Each company believed if they were telling us what we should do, then why do it at a university?"

Patterson brings up the success of DARPA's Grand Challenge competition [see "Hard Drive," News, *IEEE Spectrum*, December 2005]. Sending autonomous robotic vehicles in an endurance race across the Mojave Desert, it was a "milestone in machine learning," he says. Now, "we want to use that same technology to help us manage and operate computer systems."

The good news, he says, is that "I'm even more excited about this field than I was two years ago." An avid surfer, he likens it to catching a big wave. "You'll look at this wave on the horizon, and it's starting to peak some, and so you have to decide if you start paddling. But if you pick a good wave, the wave gets bigger, and it takes you a long way," Patterson says. "This wave is definitely getting bigger."

—**JEAN KUMAGAI**

Mars Gets Broadband Connection

New orbiter will provide future missions with high data rates

When NASA's *Mars Reconnaissance Orbiter* reaches the Red Planet next month, it will immediately seek out areas where water once flowed, try to identify habitats where ancient life might have thrived, and start mapping the entire planet in unprecedented detail. But the orbiter's arrival at Mars will also set the stage for a new epoch in spacecraft telecommunications. Its onboard Electra UHF relay transceiver [see photo, "Relay"] will serve as an engineering test bed for new communications and navigation technology that will be required for all future orbiters, landers, and rovers, to provide the faster data rates required for transfer of information from rovers and landers on the Martian surface to orbiters circling above.

The early Mars landers, like the 1976 *Viking* and the 1997 *Mars Pathfinder*, sent data directly back to Earth using X-Band antennas that could manage no more than 1 to 10 kilobits per second of data. But when *Spirit* and *Opportunity* landed on Mars in January 2004 to explore its surface, they carried cameras that could produce dramatic panoramic pictures representing 500 megabytes of data. Accordingly, rather than transfer data straight back to Earth, their X-Band system first transferred data to the *Mars Global Surveyor* and *Mars Odyssey* orbiters, which were equipped with UHF transceivers that could support transfer rates of up to 128 kb/s.

In the new system to be tried out with the *Mars Reconnaissance Orbiter*, once the orbiter receives data from a lander or rover it will transmit the information back to a series of large radio telescopes located on Earth, the Deep Space Network. The orbiter's 3-meter-long high-gain antenna and 100-watt transmitter will be able to send data at up to a maximum of about 6 megabits per second at the minimum Earth-to-Mars distance of 55.7 million kilometers and roughly 0.6 Mb/s at the maximum distance of 401.3 million kilometers. The *Mars Reconnaissance Orbiter* has 160 gigabits of solid-state memory and a processor able to operate at up to 46 million instructions per second, to store and manipulate data obtained from craft on the surface of Mars.

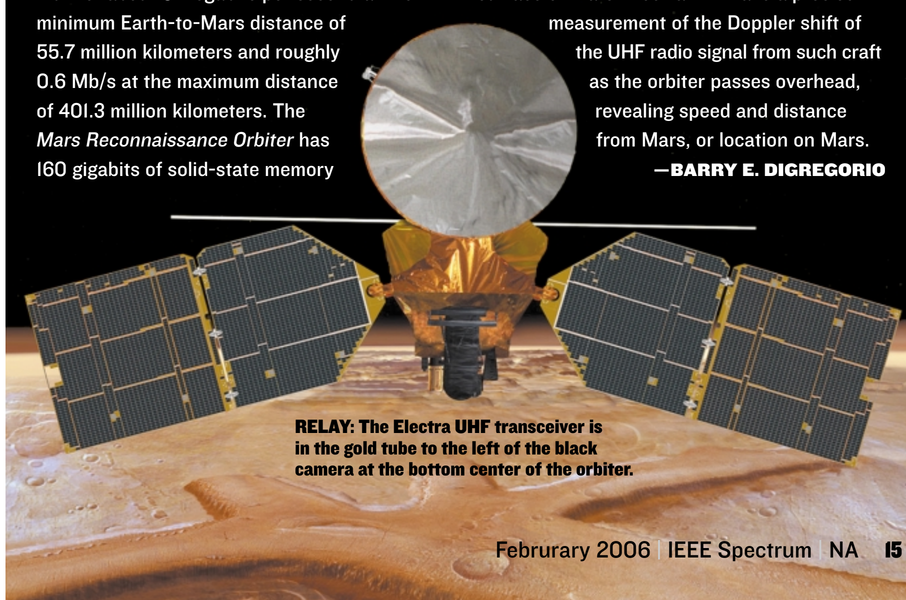
The first Mars rover to make use of the Electra system will be the *Phoenix Mars Lander*, scheduled to land in the north polar region of Mars in May of 2008. But because this lander was built using spare parts from the canceled 2001 Surveyor Lander mission, it is not outfitted with an antenna capable of communications with Earth. Instead, *Phoenix* will transmit all its data to Electra on the *Mars Reconnaissance Orbiter*, which will forward it to Earth.

The 2009 *Mars Science Laboratory* rover will be the most sophisticated rover ever sent to Mars and will also be the first rover to have its own scaled-down version of the Electra transceiver, called Electra-Lite. Built as part of a successful partnership between NASA's Jet Propulsion Laboratory, in Pasadena, Calif., and the Space Division of L-3 Communications Cincinnati Electronics, in Mason, Ohio, Electra will carry the first in-flight reprogrammable software designed for use in a long-lived Mars telecommunications relay infrastructure.

Thus, it "offers a highly capable, flexible, and evolvable framework for relay communications in support of Mars exploration," says Chad Edwards, the Mars chief telecommunication engineer at JPL. New error-correction codes can be implemented at any time during a mission, and protocols can be modified in response to unforeseen developments.

Besides serving as a transceiver for all Mars missions currently planned, Electra will also provide a navigational or locational beacon for incoming spacecraft or any craft on the surface of Mars. Electra will make a precise measurement of the Doppler shift of the UHF radio signal from such craft as the orbiter passes overhead, revealing speed and distance from Mars, or location on Mars.

—**BARRY E. DIGREGORIO**



RELAY: The Electra UHF transceiver is in the gold tube to the left of the black camera at the bottom center of the orbiter.

NASA/JPL