French involvement may boost Mars studies

The trouble with designing a planetary mission several years in advance is that the spacecraft may not have the capability to follow up on brand-new discoveries. For instance, NASA has no plans—or money—to drill into Mars' northern lowlands, which recent evidence suggests may have been sculpted by an ancient ocean.

A proposed collaboration between the French space agency and NASA could change that.

In a plan now under negotiation, the French would spend some $400 million on Mars exploration, nearly doubling the U.S. budget for obtaining samples over the next decade and providing a number of new, small missions for studying the Red Planet.

The French space agency would fund several launches of the recently developed Ariane-5 rocket and supply most of the parts for a Mars orbiter, already scheduled to carry Martian soil and rock cores back to Earth in 2008. In return, NASA would give French scientists some of the samples.

Jacques Blamont, chief adviser at the National Center of Space Studies (CNES), the French space agency in Paris, says that talks with NASA began last October and that details of a collaboration were fleshed out during a meeting in Paris in early March. The plan is now under review at NASA and at CNES, and an agreement is expected by the end of the year.

"The idea is to augment the science of the Mars program," says Blamont. "It would open up the possibility of doing something other than just sample-return [missions]."

Indeed, NASA's focus on Mars in the next decade is to bring a pound or so of the planet back to Earth. Rovers stowed on spacecraft scheduled for launch in 2001 and 2003 are to gather and store samples, and a mission set for 2005 is expected to retrieve one of the two caches. A $500 million budget cap has imposed this single-minded approach to Mars studies, notes Daniel J. McCleese, chief scientist of Mars exploration programs at NASA's Jet Propulsion Laboratory in Pasadena, Calif.

"The additional opportunities [with the French] will revolutionize the strategy," says McCleese. "We have much more flexibility to take advantage of the [information from] missions leading up to the sample return if we have additional launch capability and partners who have their own science capability that supports ours or is outside our reach."

The Ariane-5 class of rockets has not yet proven its reliability. One of them, along with its $800 million science payload, spun out of control in 1996 (SN: 7/27/96, p. 59). However, the rocket design should have enough time to prove its mettle by 2001, notes Blamont.

If NASA gets a free ride on Ariane-5 launches, the money saved could bolster the capabilities of Mars-bound craft now under development. For instance, notes McCleese, the vehicle scheduled to retrieve material collected by the 2001 and 2003 rovers might be equipped with tools to gather its own samples.

The NASA-CNES proposal also calls for new missions that would piggyback on Ariane-5 rockets already scheduled for commercial flights between 2001 and 2005. These micromissions might include a device that could drill as deep as 10 meters into the Martian surface. "These are way-out technologies, but that's what we're looking at for this series of missions," says McCleese. As a result of the missions, "new samples might be returned from sites that are just being discovered," he adds.

In a separate proposal, the Italian space agency and NASA are considering a collaboration on a radar experiment that would fly on Mars Express, a European Space Agency mission scheduled for launch in 2003. The experiment would search for water beneath the surface of Mars. *—R. Cowen*

Magnetic materials keep fridges cool

Magnets turn many refrigerators into message centers and art galleries—holding up notes, shopping lists, and the kids' latest masterpieces for all to see. Someday, magnets may not only adorn the outside of refrigerators but also power the inner workings of the appliances.

Magnetocaloric materials, which change temperature in response to an applied magnetic field, form the heart of a new class of refrigeration technologies. Magnetocaloric refrigerators have the potential to be more efficient than conventional devices without relying on ozone-depleting coolants (SN: 9/6/97, p. 152).

Materials now available perform their best in the powerful fields supplied by superconducting magnets, so the first applications will probably be in industry rather than home kitchens. Researchers presented a selection of recent findings at the American Physical Society meeting in Los Angeles last week.

Carl Zimm and his colleagues at the Astronautics Corp. of America in Madison, Wis., have constructed a prototype magnetocaloric refrigerator in collaboration with researchers at the Department of Energy's Ames (Iowa) Laboratory. The field supplied by a superconducting magnet cools a piece of solid gadolinium, which in turn cools water flowing around it, says Zimm. Weaker, permanent magnets don't provide as much cooling power.

As a heat-transferring fluid, water replaces the chlorofluorocarbons or hydrochlorofluorocarbons typical of ordinary refrigerators (SN: 3/9/96, p. 151). "You can't get more environmentally safe than water," Zimm notes. The refrigerator cools a volume "about the size of a soda can," he adds. It has been running for nearly a year, which bodes well for reliability.

Gadolinium has a magnetocaloric response twice that of iron, but Ames researchers Vitalij K. Pecharsky and Karl A. Gschneidner have found that alloys of gadolinium, silicon, and germanium show a response twice again as big.

The magnetocaloric effect depends on the way a material's atomic spins align themselves. All materials store heat in the form of atomic vibrations. An applied magnetic field forces the atoms into alignment, reducing the system's heat capacity and causing it to expel energy, which the water carries away. When the field is removed, the atoms randomize again and can absorb energy from their surroundings, creating a cooling effect.

By adjusting the alloy's composition, Pecharsky and Gschneidner can control the temperature at which the effect is greatest, from near room temperature down to about 30 kelvins.

Another way to tune the magnetocaloric effect is to construct magnetic nanocomposites, says Robert D. Shull of the National Institute of Standards and Technology in Gaithersburg, Md. (SN: 4/23/94, p. 271). Scattering magnetic elements as small as 1 to 20 nanometers throughout a material changes its sensitivity to magnetic fields.

Shull has modified a magnetocaloric material, gadolinium gallium garnet, by substituting iron for some of the gallium atoms. The addition of iron tripled the material's response to a magnetic field.

The first application of magnetocaloric refrigeration would probably be for condensing hydrogen gas into a liquid for use as a clean-burning fuel (SN: 11/1/97, p. 279). The liquefaction of hydrogen would require refrigerators with about 15 separate cooling stages, combining to reduce the temperature to 20 kelvins, says Pecharsky. This method's greater efficiency will lower costs significantly, compared to traditional hydrogen liquefaction. Zimm estimates that it will take at least 5 years for an industrial magnetic refrigerator to become available. *—C. Wu*