which lost out to SLAC 5 years ago in a competition for government funding for an asymmetric collider, will upgrade both the CESR accelerator and its CLEO detector in the middle of next year. DESY has a B meson project of its own, says Schwarz. And across the Pacific the sun is rising on the world's other asymmetric B factory, under construction at KEK, the Japanese high-energy physics lab near Tokyo, which is likely to produce its first collisions by the end of the year.

For now, Dorfan and his team are still coaxing their new machine to its full brightness and learning how to operate it efficiently. "We're not about to start physics next week," says Dorfan. At about the end of the year, the 1000-ton BaBar detector will be slotted into place, and by next spring the machine will begin exploring the universe's fundamental bias. **–ANDREW WATSON**

Andrew Watson is a science writer in Norwich, U.K.

SPACE

Engineers Dream of Practical Star Flight

Why settle for poking through the clutter of the solar system when you can break out into interstellar space? That was the mood last week at a workshop on Robotic Interstellar Exploration in the Next Century, held at the California Institute of Technology in Pasadena and sponsored by NASA's Jet Propulsion Laboratory (JPL). Engineers took the opportunity to engage in some uninhibited thinking about practical—or, at least, plausible—ways to propel, control, and communicate with an interstellar probe.

One enthusiast is NASA Administrator Daniel S. Goldin, who has directed NASA's Office of Space Science to investigate the possibilities for interstellar flight. The notion is also getting a boost from the recent discovery of planets around other stars. Although the first interstellar probes would probably aim for nearby interstellar space, the ultimate goal would be to reach other planets within, say, 40 light-years of Earth. "If you can find them and image them, maybe you should think about visiting them," says JPL deputy director Larry Dumas.

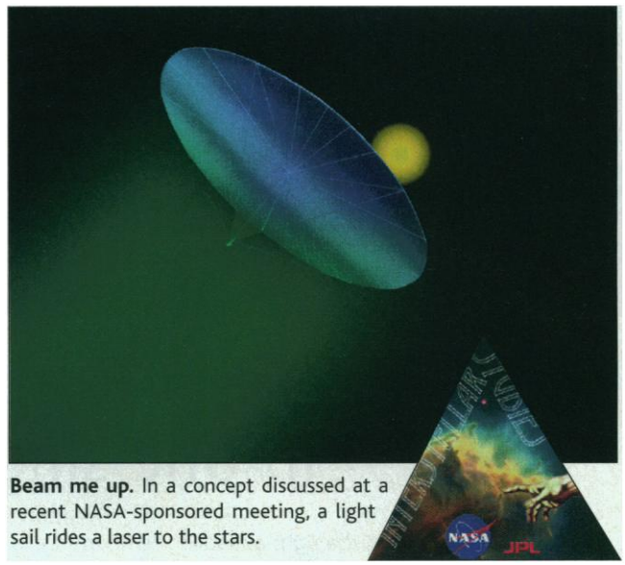
That idea, says Dumas, "is so audacious that it stimulates and confounds at the same time"—which is exactly the point, say researchers. The requirements of a journey thousands of times longer than any spacecraft has ever taken are so daunting that some people find them laughable. But even skeptics say that some of the novel propulsion, robotics, and communications concepts discussed at the meeting could pay off for travel within the solar system, if not to the stars. "I think it is enormously valuable and stimulating," says Louis Friedman of the Planetary Society in Pasadena. "I would just caution that the reality of interstellar flight is far off."

The scientific interest is already there, says Richard Mewaldt, a physicist at Caltech who spoke at the workshop. The solar system sits inside the heliosphere, a bubble blown into the ionized gases of the interstellar medium (ISM) by a wind of particles from the sun. The ISM reflects the makeup of the galaxy billions of years ago, before the solar system formed, and researchers would like to probe its composition and magnetic fields. They would also like to sample cosmic rays in the ISM, because many of them can't penetrate the heliosphere, and survey two distant reserves of comets: the Kuiper Belt just outside the orbit of Pluto and the Oort Cloud in nearby interstellar space. A spacecraft at the right location in the ISM could even use the sun as a colossal gravitational lens to bend light rays from objects in the far reaches of the universe, magnifying them. "There's science to be done all the way," says JPL's Sam Gulkis.

But just to reach the heliosphere's edge, perhaps 100 Earth-sun distances (100 AU) from the sun, in a reasonable time, a craft would need a propulsion mechanism that is thousands of times more powerful than conventional, chemical rockets yet doesn't require carrying large amounts of fuel. (Today's spacecraft would take at least 30 years to make the journey.) Three approaches have emerged as contenders, says Henry Harris, the JPL researcher who organized the workshop: thrusters or sails driven by Earth-based lasers, matter-antimatter annihilation, and nuclear power.

In the first concept, a laser fired from the ground is reflected off a mirror and focused into a chamber at the back of the spacecraft, heating gases that then rush out of a rocket to generate thrust. The concept "is very efficient, because you're leaving your engine on the ground," says Harris. Before the craft leaves Earth's atmosphere, ambient air could serve as the propellant. At the workshop, Leik Myrabo of Rensselaer Polytechnic Institute in Troy, New York, described actual flight tests in which he fired a 10,000-watt laser into a Coke-can-sized facsimile of a spacecraft and lifted it about 30 meters off the ground, says Harris. He says that million-watt lasers, which already exist, could fling objects into orbit, at a calculated cost of about $500 per kilogram for the electricity.

Outside the atmosphere, such a probe would need to carry its own supply of propellant, which could be bulky. A better strategy for harnessing laser power might be to equip a craft with a large, reflective sail that would catch and deflect the beam from a laser—or even plain old sunlight—and accelerate under the bombardment of photons. Harris, who leads a program involving several NASA labs, the Army, the Air Force, and the Department of Defense to develop space sails, calculates that a ground-based, 46-billion-watt laser firing at a craft that has a 50-meter sail could send 10 kilograms to Mars in 10 days. A billion watts "is a lot," allows Harris, with more than a touch of understatement—it's roughly the output of an average electric power station.



NASA/JPL

Beam me up. In a concept discussed at a recent NASA-sponsored meeting, a light sail rides a laser to the stars.

Another propulsion concept, based on the annihilation of matter with antimatter, faces even bigger scientific hurdles. But it too would require only small masses of fuel to power a craft into deep space—assuming sufficient quantities of antimatter could be produced and stored. Still more futuristic engines would scoop hydrogen right out of interstellar space and use it as fusion fuel.

"These three technologies may have the capability of getting us to the nearest stars in a reasonable time—10 to 100 years," says Gulkis. Once a probe gets into interstellar space, communications delays of hours, weeks, or years rule out controlling the spacecraft from the ground. So other talks at the workshop dealt with ways to get an interstellar probe to operate autonomously during its long, lonely voyage. Another challenge comes at the journey's end: sending back data across a distance of light-years. Laser beams aimed at Earth might be the answer, some participants suggested. Because the lasers could be more tightly focused than radio beams, they could in prin-

ciple be millions of times more efficient.

"The programmatic requirements are daunting," concedes Goldin. But if researchers meet the challenge, "it opens up the prospects for some truly innovative missions," he says. "It may be a probe to sample the interstellar medium ... or a mission to explore the Kuiper Belt. But one thing is for sure: It will literally be out of this world."

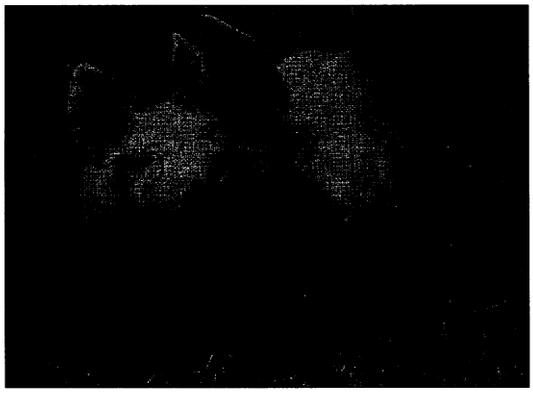
–JAMES GLANZ

BIOTECH REGULATIONS

Paving the Way for British Xenotransplants

The transplantation of animal organs into humans moved a step closer in Britain last week, when the government circulated to hospitals a set of national guidelines intended to ensure that proposed clinical trials don't put patients or the public at risk of new diseases. The proposed trials remain highly controversial, but by providing a regulatory framework, the new rules encourage companies to move ahead, say officials at Imutran, a Cambridge-based company working toward eventual xenotransplantation trials.

IMUTRAN



Safe for transplant? Tissue from these genetically engineered pigs sparks a reduced immune response from humans.

Xenotransplants could help meet a serious shortage of donor organs: Globally, only one person out of every three who need new organs will find a donor this year. Organs from animals such as pigs could make up the deficit. Although the human immune response would normally destroy transplanted animal tissue, researchers can now produce "humanized" animal organs from pigs; the pigs have been genetically engineered so that their tissue doesn't produce the molecules that trigger an early portion of the human immune response.

But there are concerns that animal tissues might harbor hidden pathogens, which might pass from animal to human and threaten patients or even the general public. For example, studies at the Institute for Cancer Research in London have found that in the test tube, a pig retrovirus can infect human cells, raising fears that such retroviruses could pass to xenotransplant recipients. "It is a question of balancing the needs, which are real because there are never going to be enough human transplants, against the possible dangers of using animals," says Lord Habgood, chair of the U.K. Xenotransplantation Interim Regulatory Authority (UKXIRA) and a former bishop of York who trained as a pharmacologist.

In the United States, these worries have led the Food and Drug Administration to consider xenotransplants among the other biomedical technologies it regulates, but in Britain the regulatory machinery had lagged behind. Now Britain has its first national review procedures for assessing xenotransplant risks. All applications for clinical trials will be scrutinized by the authority, which will then make a recommendation to the health minister for a final decision. Human trials will take place only "if and when we are fully satisfied that the risks associated with such procedures are acceptable, taking account of all the available evidence at the time," Health Secretary Frank Dobson said. UKXIRA is also building up a long-term surveillance plan to monitor any infections arising from xenotransplants. Their recommendations are only advisory at the moment, but Dobson said that they may become legally binding if there's a great deal of public concern.

Animal rights organizations, which oppose the use of animals as organ donors, said the new rules were "a very backward step in terms of animal welfare [that] could pose serious health risks to the human population," as Mike Baker, chief executive of the British Union for the Abolition of Vivisection, put it. But biotech companies welcomed the new framework. Officials at Imutran, which is now a division of the Basel, Switzerland–based biotech giant Novartis, say that the path toward trials is now more straightforward, as it's easier to deal with a standardized national approach.

Imutran researchers are scanning for pig viruses in 160 patients worldwide who have received small portions of pig tissue, such as blood vessel valves; they are also studying monkeys that received pig grafts. If the results, expected later this year, are promising, the company will apply for a human trial. The first such trials may examine the benefits of using a "humanized" pig liver outside the body as temporary support for a patient awaiting a human organ.

–NIGEL WILLIAMS

SCIENCE POLICY

USGS Nominee Breaks Ground

The White House has tapped a new chief for the U.S. Geological Survey (USGS), the Interior Department's science agency. Last week President Clinton announced his intention to nominate Charles Groat, a geologist who's a familiar face in policy circles but little known among researchers.

Top USGS stratum. Charles Groat.

Groat, associate vice president for research at the University of Texas, El Paso, has headed Louisiana's geological survey, served on several National Research Council panels, and spent 2 years as the American Geological Institute's executive director. Groat says it's a "fair appraisal" that his expertise lies in "applications of science to decision-making." He adds: "That's frankly what I think the survey needs more than anything else."

Some grumble that Groat lacks the research muscle of past USGS directors. As a rule of thumb, "the best thing for the survey is someone whose scientific credentials are unimpeachable," says Debra Knopman, a former Interior official and USGS geologist now at the Progressive Policy Institute in Washington, D.C. "You want someone who's above the fray." Sources say Groat's name may not have been on a secret list of potential directors provided to Interior by the National Academy of Sciences. Interior Secretary Bruce Babbitt declined to comment, but defended Groat's scientific credentials: "Look at his bio—what he's done and where he's taught," he said.

Others say Groat could give the embattled agency a boost. His "policy experience will bring a new perspective to the role of USGS director," says Mary Lou Zoback, a USGS geophysicist in Menlo Park, California. USGS is coping with staff cuts and a drive to make it customer-oriented (*Science*, 19 September 1997, p. 1755). Moreover, the agency has always struggled to defend its mission, which includes mapping, hydrology, seismology, volcanology, and—since the National Biological Service was folded into it in 1996—biology. Indeed, 3 years ago Congress came within a hair of eliminating USGS. If confirmed by the Senate, Groat says he plans to "raise the profile" of the agency—without cutting science: "The issue is making sure the fundamental science is aligned with what the future needs are."

–JOCELYN KAISER