SPACE SCIENCE

ESA Plans for the Early 21st Century

PARIS—The European Space Agency's (ESA's) current space science program, known as Horizon 2000, has more than a decade yet to run, and its next two key missions—a gamma ray observatory and a comet rendezvous/asteroid flyby mission—are still in their planning phases. But for planners of space missions, a decade is not a long time. So this week ESA officials unveiled Horizon 2000 Plus, an ambitious new program that will keep the agency busy until 2016. But in its attempt to cover a wide spectrum of scientific disciplines—missions range from a Mercury probe to a gravity wave detector—ESA may find itself stretching the resources of its 13 member-states. Indeed, representatives of some of those countries have already indicated that they will be looking for economies when they have to approve the program next fall.

Horizon 2000 Plus was drawn up by a survey committee of 19 scientists, assisted by almost 60 others in various working groups; it defines three large core missions as well as provisions for a number of smaller ones. As with ESA's plans for renewed exploration of the moon, announced earlier this year (*Science*, 3 June, p. 1396), the agency wants to maintain a fair degree of independence from such international partners as the United States and Russia. "We can't gauge our long-term planning on what others will do," says Lodewijk Woltjer, an astronomer at the Haute Provence Observatory in France and chair of the survey committee. "With the major projects, we looked for ones that Europe could execute by itself." But ESA will not be spurning outsiders completely: It will seek to collaborate with non-European countries in Mars exploration and solar physics studies, as well as explore the possibility of a high-energy astrophysics facility on the international space station.

Perhaps the most eye-catching core mission is the Mercury probe, which would involve an orbiter—and possibly a landing craft. Mercury has not been closely explored since NASA's Mariner 10 photographed about 40% of its surface in 1974. Very little is known about the composition of the planet's surface or about its magnetosphere, the region above its surface where charged particles are trapped by the planet's magnetic field. And because Mercury is the planet closest to the sun, "it must hold keys to the origin of the solar system," says Woltjer.

For astronomers, ESA plans an orbiting observatory which would use advances in stellar interferometry—the technique of merging signals from detectors placed far apart to give high-resolution images—to provide detail as fine as 1 microarc second. "That's more than 1000 times better than you can ever hope for with the Hubble telescope," says Kenneth Pounds, chief executive of Britain's Particle Physics and Astronomy Research Council. The observatory could greatly improve our knowledge of the movement and positions of stars, as well as aid in the search for other planetary systems. And the use of infrared interferometry might allow astronomers to view events that occurred during the early infancy of the universe.

The third and perhaps most ambitious core mission—a search for the gravity waves predicted by Einstein's theory of general relativity but yet to be definitively detected—could comprise as many as six spacecraft spread out over a million kilometers of space. The craft would be in constant communication via laser beams, allowing them to detect perturbations in their orbits caused by the postulated gravity waves.

Although the Mercury exploration and stellar interferometry projects could be carried out on ESA's current annual core science budget of $398 million, venturing into the fundamental physics of gravity waves would require significant additional funds. But Roger Bonnet, ESA's director of scientific programs, says that the agency is "not asking the ministers for more money before 2000." The survey committee has proposed that the science budget be held at its 1994 level until 2000, then increased by between 4% and 5% per year for the following 4 to 5 years. However, they may have to fight hard to get agreement for that raise from some of ESA's cash-strapped members—particularly the United Kingdom and Germany.

The proposed increase "is highly unrealistic," says Pounds, and his research council has already warned that Britain might not be able to afford to participate in some Horizon 2000 missions it is already committed to. While accepting that there is "a definite pressure on the science budget," Bonnet is optimistic that when the member nations' government ministers responsible for space science meet next fall to approve the whole ESA budget, they will look beyond the current financial crisis. "This is a short-term problem," he says.

–Michael Balter

Michael Balter is a science writer in Paris.

GENOME RESEARCH

Plans for Tunisian Institute Move Ahead

Gene mapper Daniel Cohen of the Centre d'Etude du Polymorphisme Humain (CEPH) in Paris says he never wanted to be a geneticist; his dream was to be a musician. Music and science can be difficult to combine, but recently, Cohen has had ample opportunity to do just that. As part of a drive to raise funds for a scientific organization he's masterminded—the Association Ifriqya, whose mission is to establish institutes of molecular biology in Africa—Cohen plays the piano for potential benefactors.

FRANCOIS MARIT/AFP

Into Africa. Daniel Cohen hopes to improve research in Tunisia.

Perhaps Cohen could have had a career as a musician after all, as his piano playing appears to be paying off. Association Ifriqya has now raised from musically-inclined private donors the $1 million needed to start building the first such institute. In the new year, the association plans to break ground on the Institute for Genome Research for Developing Countries (IGRDC) in Hammamet, Tunisia, said Cohen at *Science*'s genome meeting, "The Genes and Beyond," held earlier this month in Washington, D.C.

IGRDC is scheduled to open its doors in 1996, assuming Cohen can raise an additional $4 million to complete the institute's buildings—a goal even he concedes will test his fund-raising talents to their limits. In the meantime, Association Ifriqya will begin training the first of 15 scientists from Tunisia and other parts of Africa at CEPH and the Sloan-Kettering Institute in New York City for future work at IGRDC.

If IGRDC does come to pass, it will be one of the first tangible responses to the frequently voiced concern that developing countries are gaining nothing from the molecular biology revolution. IGRDC will be "an African center of excellence for molecular biology," as well as a means of "transferring technology from the First World to the Third World," says Sloan-Kettering's Jeffrey Ravetch, who's played a leading role in planning IGRDC's scientific program. IGRDC's first research target will be to complete the map of the genome of *Plasmodium falciparum*, one of the parasites that cause malaria (*Science*, 24 June, p. 1848), killing millions of

people each year in the developing world.

But to meet that target, Association Ifriqya will have to surmount formidable hurdles. Creating an international center of excellence is easier said than done, warns Robert Walgate, a spokesperson for the tropical disease research program at the World Health Organization (WHO). Walgate cites the Ndola Center for Tropical Disease Research (CTDR) in Ndola, Zambia, which received $10 million from WHO during the 1980s. In the absence of the necessary infrastructure—for example, a local network of research institutes to ensure that company technicians would come to the region to service laboratory equipment—CTDR "never fulfilled its promise of being an international center," Walgate says. In the end, WHO decided to discontinue funding CTDR, which now conducts epidemiological research and surveillance for Zambia. But Cohen expects fewer problems in Tunisia, one of the most scientifically advanced of the African countries. "Tunisia has lots of universities, a Pasteur Institute, and research hospitals. It's not a typical African country, but it's the best place to start," he says.

But there is still the question of money. In addition to the $4 million needed to complete the IGRDC buildings, Cohen estimates it will cost $5 million a year to run the institute—and at the moment, it's not clear where those funds will come from.

IGRDC plans to seek support from the agencies that traditionally make funds available internationally, such as the European Union's research directorate. Until IGRDC has proved itself, however, those sources of funding are unlikely to be generous. To meet the expected shortfall, Cohen plans to continue tapping his private donors, while cajoling institutes engaged in genome research in industrialized countries to donate 2% to 5% of their budgets. Cohen admits it's not easy to get institutes to cough up. Indeed, even the CEPH board refused to part with 2% of its budget—about $200,000—until the French minister of higher education and research François Fillon made clear his support for research in developing countries, says Cohen. Nonetheless, some institutes are taking Cohen up on his proposal.

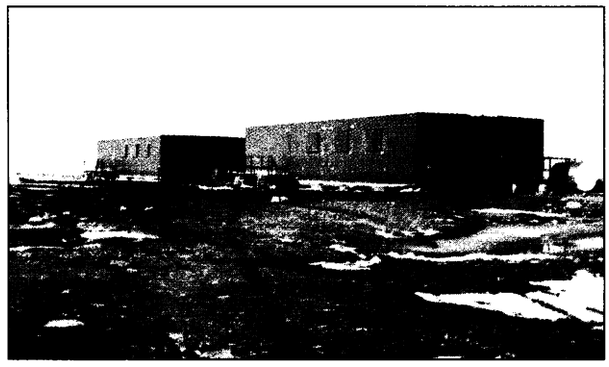
"I haven't made a dollar commitment yet, [but] we've discussed it and [The Institute of Genomic Research (TIGR)] is going to try and do something," says Craig Venter, director of TIGR, the private genome research institute in Gaithersburg, Maryland. "I've also offered to help [Cohen] raise funds." Cohen, meanwhile, is planning to follow up on his earlier successes. At the next Association Ifriqya fund-raising extravaganza in February in Paris, he plans to conduct part of the orchestral version of Giuseppe Verdi's *La Forza del Destino*.

–Rachel Nowak

POLAR ECOSYSTEMS

Rustic Site Draws a Crowd To Monitor Global Warming

TOOLIK LAKE, ALASKA—On a calm day, the only sound you hear on the shore of this steely blue lake 170 miles above the Arctic Circle is your lungs filling and emptying. The bustle of civilization lies hundreds of miles to the south of this treeless, frozen land, below the rough-hewn Brooks Range that separates Alaska's North Slope from the rest of the world. But the mountains are no longer an impediment to a growing number of scientists who believe that some of the hottest action in long-term climate change is going to occur at the poles. Backed by the National Science Foundation (NSF), they are streaming to Toolik Lake to characterize a swath of the North Slope environment before human activity refashions it and obliterates the baseline data. "We want to use the Arctic as a canary in the mine," says Bruce Peterson, a stream ecologist at the Woods Hole Marine Biological Laboratory (MBL) who has spent 17 summers at Toolik.



R. G. WHITE/UNIVERSITY OF ALASKA, FAIRBANKS

Tundra dacha. Toolik's new labs will accommodate more researchers and better chemical analyses.

Peterson and his colleagues are willing to brave the rudimentary facilities and forbidding isolation because they think Toolik, an Eskimo word for the yellow-billed loon, is one of the best places on Earth to study a pristine ecology that may be on the brink of a major upheaval. Most global climate models are now predicting that over the next two centuries, rising levels of greenhouse gases such as carbon dioxide and methane, spewed into the atmosphere by industry, agriculture, and transportation, could raise Arctic temperatures by as much as 6 degrees Celsius in the summer and 12 degrees in the winter—several times that predicted for the temperate climes. "These areas are going to be the bellwethers of global warming," says University of New Mexico stream ecologist Cliff Dahm, who this summer studied the interaction between ground water and surface water in two Toolik tributaries.

But the scientists may not have long to gather their data. The Arctic's climate may already be changing: The average surface temperature of Toolik Lake during the summertime has risen nearly 3 degrees in the past 15 years. Although nobody knows whether the region is experiencing global warming or merely a short-term temperature blip, the heat already appears to have triggered an effect. The Arctic tundra, for thousands of years a carbon "sink," has begun in the past decade to release carbon dioxide as warmer air dries the tundra and causes better aeration of the upper soil layers. "This is almost assuredly tied to the temperature increase" at Toolik, says San Diego State University ecologist Walter Oechel. And researchers fear that more pronounced warming could increase plant production as well as thaw millions of acres of permafrost, releasing an unknown portion of the estimated 180 billion metric tons of carbon in Arctic soil and fundamentally altering Arctic ecosystems.

However, this scenario appears to be more complex than researchers have envisioned. New data from Oechel's team published earlier this month (*Nature*, 6 October, p. 500) found that tussock plots at Toolik did release carbon dioxide in the presence of elevated atmospheric levels of the gas. However, when temperatures at the plots were raised by a few degrees, carbon dioxide loss from the ecosystem was much less. The findings, taken over 3 years, suggest that regions of the Arctic that remain moist, like the experimental plots, may release less carbon than predicted if global warming were to occur. But climate models also predict that much of the tundra is expected to become drier than the experimental plots and, thus, more likely to release carbon dioxide. More sustained experiments, Oechel says, are needed to understand the delicate Arctic ecosystems.

Ecologists are discovering just how delicately balanced those ecosystems are. A decade ago, a team led by Peterson and John Hobbie, co-director of MBL's Ecosystems Center, began adding small amounts of phosphorus to the Kuparuk River, a stream that