and sea temperatures compiled by climatologists at the National Climatic Data Center (NCDC) in Asheville, North Carolina. Last year was 0.08°C warmer than its rivals, announced Thomas Karl, a senior scientist at the NCDC. Since 1900, the same record shows that Earth has warmed by about 0.5°C. The year would not have been a record-breaker if El Niño had not warmed the ocean surface, Karl noted, but it was still one of the five warmest years over land since 1880.

The margin of victory was a lot slimmer—a statistically insignificant 0.01°C—in another analysis of global temperature announced this week by climatologist James Hansen of NASA's Goddard Institute for Space Studies in New York City. The two analyses agree, however, that it has been especially warm lately. Hansen found that the four warmest years on record all fell in the 1990s; in the NCDC analysis, nine of the past 11 years have been warmer than any previous years on record.

But computer climate models predicting the effects of rising greenhouse gases suggest that the globe should be warming even faster—about twice as fast as observed. Pollutant hazes from the burning of fossil fuels, forests, and agricultural lands are moderating the warming by blocking sunshine, as did debris from the eruption of the Mexican volcano El Chichón in 1982 and Mount Pinatubo in the Philippines in 1991. The destruction of stratospheric ozone by chlorofluorocarbons (CFCs) is cooling the atmosphere from the lower stratosphere down, because ozone absorbs incoming solar radiation and blocks the escape of heat. And even the slight, cyclical brightening and dimming of the sun may affect temperatures.

In the November 1997 issue of the *Journal of Geophysical Research*, Hansen and his colleagues took their best shot at modeling these cooling effects between 1979 and 1996. They only left out pollutant aerosols, whose changing abundance is too uncertain to factor into the models. In that period, they calculate, the known cooling effects completely offset the warming effect of added greenhouse gases. The warming observed—a modest 0.2 degrees—was probably a carry-over from previous decades, says Hansen, when greenhouse gases increased rapidly but the heat-absorbing oceans delayed their warming effect.

In coming years, the sun should warm slightly as it heads toward a sunspot maximum, ozone depletion should level off as CFC controls take hold, and the oceans can retard greenhouse warming only so much. Meanwhile, greenhouse gases will continue to rise. Unless another massive eruption spews a global sunshade, Hansen and his colleagues have "an expectation of new record global temperatures in the next few years."

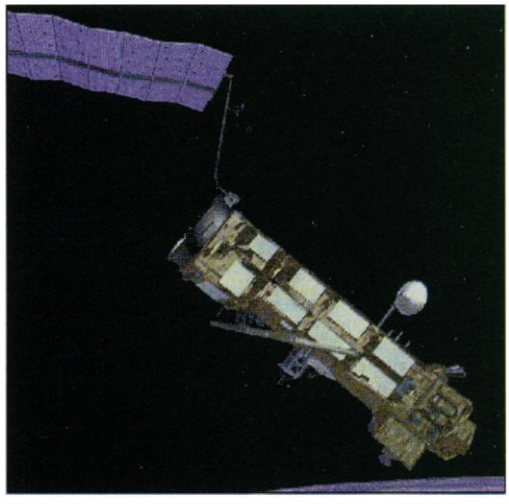
–Richard A. Kerr

EARTH OBSERVATION

Europe Forges a Plan in Collaboration With Industry

When Antonio Rodotà took over as head of the European Space Agency (ESA) last summer, he promised to forge a new relationship between the troubled agency and Europe's aerospace industry. Last month, an ESA task force outlined a new strategy for supporting Earth-observation missions that would more than fulfill Rodotà's pledge. It would make industry a full partner in designing, developing, and funding an entire class of missions.

The proposal, previewed at a crowded meeting of industrialists at ESA's science and technology center (ESTEC) in Noordwijk, the Netherlands, on 18 December, would divide future Earth-observation programs into "Earth Explorer" missions, which are mostly scientific, and "Earth Watch" missions, geared toward applications and operational uses. Explorer missions—which have yet to be defined in detail—would be fully paid for out of ESA's budget. It is the Earth Watch missions that would mark a radical departure from the agency's usual way of doing business. David Southwood, a physicist from London's Imperial College who is coordinating ESA's strategy, told the gathering that these missions would either be private initiatives supported by a strong business plan, in which case ESA would provide expertise, facilities, and some money for technology development, or be risk- and cost-sharing partnerships between the agency and industry. ESA would only join such partnerships if the industrial sponsors have purchasers for the data lined up, said Southwood.



ESA

End of an era. ENVISAT will be the last of ESA's currently scheduled remote-sensing satellites.

This new plan, which will be fleshed out at ESA headquarters over the next few months and presented to the organization's member states this summer, is designed to fill a looming gap in ESA's Earth-observation program. Until now, ESA's efforts in Earth observation have been somewhat ad hoc. The agency launched its first remote-sensing satellite, ERS-1, as late as 1991, and although that mission and its sister, ERS-2, have been highly successful, they were driven more by technology than the need for a particular type of data. ESA has only one more remote-sensing mission under way: the giant multisensor ENVISAT—conceived as part of Europe's contribution to the space station—due for launch in 1999. "The need for a strategy is a major issue," says Alain Gaubert, secretary-general of the Paris-based trade group, Eurospace. "There is nothing planned beyond the year 2000."

The seeds of ESA's emerging strategy were sown in November 1995 at a meeting in Toulouse, France, of government ministers responsible for space from all of ESA's 14 member states. The agency issued a statement jointly with the European Commission and the European Meteorological Satellite Organisation calling for a long-term Earth-observation strategy that would spawn both scientific and applications satellites and would foster Europe's space industry "as it went through consolidation and regrouping." Without support, the statement said, European industry would find it hard to compete with the more mature U.S. space industry, which was also the beneficiary of technology developed with large military budgets.

ESA's response was to form a task force last June, supported by an industrial working group. Both comprised senior figures in European space policy. "We inherited the Toulouse statement," says Roy Gibson, ESA's first director-general and the only person on both the task force and the working group. Last October, ESA appointed Southwood, a former chair of the committee that plans ESA's space science program, to head the task force and oversee development of the Earth-observation strategy.

Last month's meeting at ESTEC revealed the first hints of the task force's thinking. One clear message was that industry should bear a large part of the costs of applications programs. "We are saying to industry, we have finally heard what you are saying; let's see if you mean it," Southwood told *Science*. "Joint funding has to happen or nothing happens. It will be a salutary experience for both sides, and it will be equally instructive if nothing happens." An-

other message was that the final users of data should play a central role in planning missions. "We are not allowing missions to be technology driven by people saying we can build a better sensor, so let's do it," says Southwood. "We start from the point of view of the users."

ESA has challenged Europe's space industry to come up with ideas for Earth Watch missions, including funding plans, by mid-February, and these ideas will be incorporated into the overall Earth-observation strategy to be presented to ESA member states this summer. In addition to the partial industry funding for the chosen Earth Watch missions, member states will be invited to participate on a mission-by-mission basis—in much the same way that programs such as Ariane and the space station are funded now. "Without some external funding [other than ESA]," says Southwood, "I don't think the ministers will implement the Earth Watch program."

Some details of the ESA-funded Earth Explorer missions were also revealed at the Noordwijk meeting. Like ESA's Horizon 2000 space science program, it will comprise both large missions and small satellites selected to complement the scientific work being undertaken by other national and international agencies. For the first time, ESA is proposing that Earth observation receive multiyear funding, freeing the agency from the need to go back and negotiate with member states for every instrument or small satellite, allowing greater flexibility and freedom to plan.

ESA has already carved out some cash from its existing budget for a preliminary study of four proposed missions in the areas defined as Earth Explorer themes: climate studies, Earth's interior, geosphere/biosphere, and environmental change. If the strategy is approved, one mission will be selected in about 18 months; it will be the first of a series of Explorers to be launched every 2 years, starting in about 2004.

One still unresolved question is how these missions will be selected. In the Horizon 2000 program, the scientific community itself picks what missions to back. But Claus Göran Borg, chair of the European industry association of remote-sensing companies, argues that Earth-observation programs should be treated differently. "The whole name of the game is to respond to Europe's needs. This means that there must be a balance between science and politics. In my personal opinion, applications must direct the science." ESA has not yet revealed its thinking on mission selection, but full details of the strategy are due to be released in the next few weeks.

> **"We are saying to industry, we have finally heard what you are saying; let's see if you mean it."**
>
> **—David Southwood**

All this would come at a bargain price. The total budget for the entire strategy, including Earth Watch, the Explorer program, and accompanying technology development, would be about $430 million by 2005—only two-thirds of the amount ESA is currently paying for Earth observation during the construction phase of ENVISAT.

Reaction from industry and the remote-sensing community has been positive. "The plan so far sounds sensible," says Philipe Masson, an adviser to the French government and a member of the European Science Foundation's space science committee. "This approach fits the trend all over Europe, that governments set policy and industry pays for development," says Borg. "On a strategic level," he adds, "it is sensible that Europe contributes to the world capacity in Earth observing and does not leave it to the Americans or Japanese."

–Helen Gavaghan

Helen Gavaghan is a writer in Hebden Bridge, U.K.

PLANT BREEDING

Biotech Firm in High-Nicotine Intrigue

A small biotech company that specializes in creating miniature vegetables was named last week as a conspirator with an unidentified tobacco company in an alleged scheme to produce a high-nicotine tobacco plant. In a "criminal information" filed on 7 January in Washington, D.C., the U.S. Department of Justice accused DNA Plant Technology Inc. (DNAP) of Oakland, California, of surreptitiously shipping seeds of a tobacco plant called Y-1—a strain that has twice the nicotine content (6%) of normal tobacco—to Brazilian growers during the 1980s.

The Justice Department said in a statement that DNAP is cooperating with federal prosecutors and has agreed to accept a $200,000 fine for a misdemeanor violation of federal law on seed exports. The law, which was repealed in 1991, forbade U.S. growers to export tobacco seeds without a permit. Justice is pursuing this case, government officials say, because it aims to show that tobacco companies tried to manipulate the nicotine in cigarettes.

DNAP spokesperson Michael Vernetti says DNAP signed a contract in 1983 to perform research for a tobacco company, and that DNAP "worked on Y-1 ... pursuant to this agreement" until the contract was terminated in 1994. The Justice Department has not publicly identified the firm it is pursuing as an "unindicted co-conspirator" in the Y-1 project, but government officials confirmed reports that it is the Brown & Williamson (B&W) Tobacco Corp. of Louisville, Kentucky. B&W officials declined to comment other than to confirm that B&W has used Brazilian-grown Y-1 tobacco.

According to a government official who asked to remain anonymous, investigators stumbled onto the Y-1 project in 1994 when the Food and Drug Administration (FDA) was looking into allegations that tobacco companies manipulated the nicotine content of cigarettes. Under former FDA chief David Kessler, the agency argued that cigarette firms should be regulated as drug marketers because they were regulating the level of nicotine—an addictive drug—in their products. The companies denied the charges.

When FDA sleuths began digging into B&W's records, according to the government official, a B&W employee urged them to look into the Y-1 project. After scouring foreign patent registries, FDA found a Brazilian patent describing the plant. One inventor was a researcher at DNAP, a firm known for engineering specialized fruits and vegetables, such as miniature carrots and peppers, sold under the brand names FreshWorld Farms and VegiSnax. According to the government official, DNAP staff explained that the company had been recruited by B&W to breed a sterile form of Y-1. Government officials allege that B&W, which created the Y-1 strain, wanted to ship the plant to foreign growers but retain control of production by making it sterile.

DNAP collaborated with the tobacco company, according to the Justice Department statement, and shipped Y-1 seeds—under code names such as "winter trials" and "special material"—to Brazil by courier. Vernetti confirms that DNAP accepts responsibility for violating the seed-export law.

When confronted with this evidence in 1994, the government official says, B&W executives denied that they were developing Y-1 as a means of altering nicotine levels. Instead, the official says, they claimed that Y-1 tobacco was a "blending tool" used to lower the tar content of cigarettes while keeping other qualities stable. This explanation is likely to come under closer scrutiny as federal prosecutors pursue the FDA's allegations against the tobacco companies. And by raising the specter of criminal conduct in the tobacco industry, the high-nicotine flap could undermine a proposed moratorium on lawsuits against cigarette firms to be reviewed in Congress later this year.

–Eliot Marshall