research groups. And if that is a sign of the future, it would please the many researchers who are wary of a centralist approach to European integration. "We don't want to create Europe in Brussels....We don't want to create Europe in Strasbourg," says Nobel Prize–winning chemist Jean-Marie Lehn of Strasbourg's Louis Pasteur University.

It's too early to say yet just what form the decentralization of the EC's programs will take. Indeed, with the Max Planck Society backing a role for both the ESF and Euro Recherche, it's evident that the major players are keeping their options wide open. But even if the European Commission eventually decides to relinquish very few of its programs, reforms within the commission are still on the agenda. Ruberti is now talking about simplifying the EC's grant application forms and adopting regular deadlines for proposals.

Some centralized decision-making is unavoidable, of course, particularly in the planning stages of EC programs. But again, Ruberti is expected to bring a more open approach to framing the EC's research strategy. A longstanding complaint of national research agencies has been that their views aren't taken into account when EC programs are put together. But with Ruberti talking openly about the need to collaborate with national bodies, that may now change. Indeed, Peter Fricker, the new secretary-general of the ESF, sees a possible role for his organization in representing the views of national agencies during the planning of EC programs—whether or not it gets involved in their day-to-day management.

Many of the ESF's member organizations agree that this might work, but they're working on several fronts to ensure that they don't get left out of the European science policy debate. In January, the heads of most of the major research agencies from the EC member states met in Bonn to discuss the Europeanization of science—and they plan to hold another summit in London in October. If the ESF doesn't provide an effective voice in Brussels for the national agencies, promises Mark Richmond, chairman of the UK Science and Engineering Research Council, the national bodies will create an alternative.

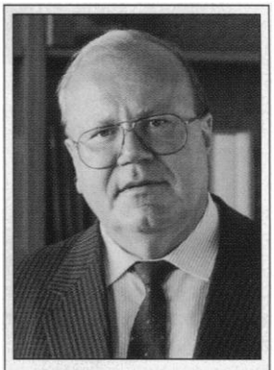
It could be some time before a stable new order crystallizes from the current melting pot of ideas. But researchers are confident that whatever system emerges will be an improvement on what's gone before. Indeed, even now that the Danes have accepted the Maastricht Treaty at the second time of asking, scientists are more concerned about the difficulties afflicting European political integration than about obstacles on the road to scientific unity. Says Franco Pacini, director of the Arcetri Astrophysical Observatory in Florence: "I wish that the political community would be as united in Europe as the scientific community."

–Peter Aldhous

INDUSTRIAL RESEARCH

A Mixed Report Card for Critical Technology Projects

BRUSSELS—In March and April, thousands of researchers were working around the clock all over Europe in a feverish effort to secure extra funding for their labs. "I would phone up [other researchers] in the middle of the night to chat because I knew they would be there," says Tim Caspell of Acorn, a small British computer company. The objective of this late-night frenzy: beating the deadline for applications to the European Community's (EC) largest research program, Esprit.



Martin Bangemann

Esprit, which covers information technology, is the oldest in a slew of international industrial research efforts launched during the 1980s on which Europe's governments now spend an estimated $3 billion a year. A large proportion of these programs are run by the European Commission, the EC's executive in Brussels, and the money it doles out, which is matched by private industry, supports collaborative research projects focused on technologies deemed critical to Europe's ability to compete with the United States and Japan. Sound familiar? Perhaps that is because similar efforts are now being ballyhooed in the United States, where they are a central feature of the Clinton Administration's R&D policies.

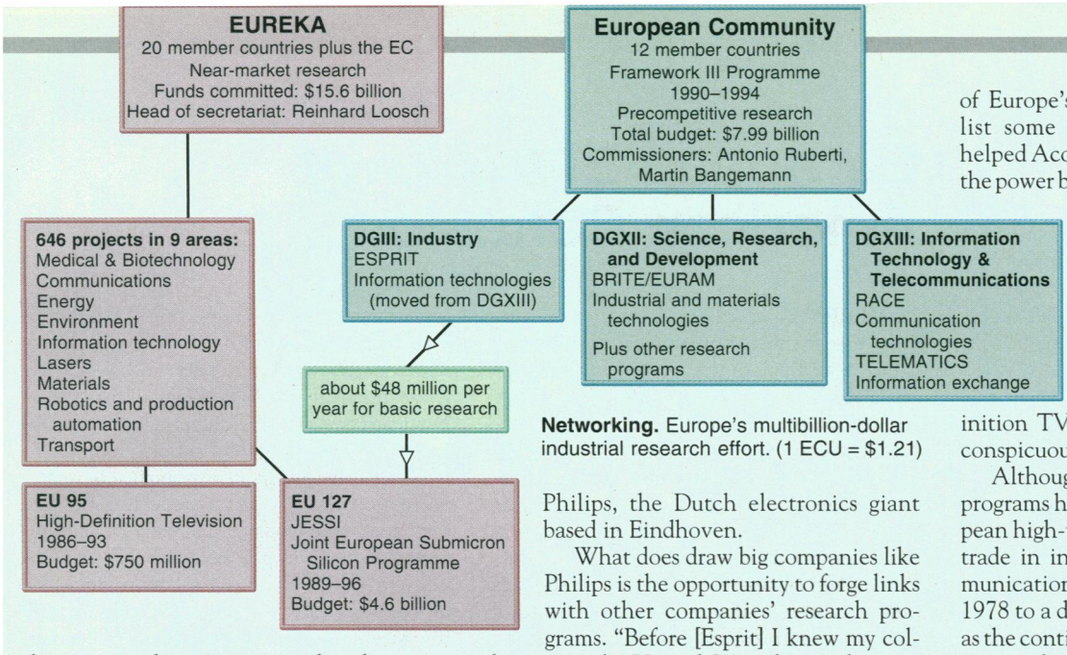
Clinton's advisers would do well to take a hard look at Europe's experience in the 9 years since Esprit was launched. The Europeans themselves have recently begun to take stock of what their investment has achieved, and the projects are getting a mixed report card. According to several recent studies, the research itself has been good and the programs have fostered a new spirit of cooperation among European companies and between industry and academia, but the programs' strategy needs a rethink to couple research more closely to the marketplace. That message is likely to get a sympathetic hearing from Martin Bangemann, the EC commissioner for industry, who has long been touting a more vigorous industrial policy for Europe. It is not the kind of message that laissez-faire economists in the United States will like to hear, however.

Pooling efforts. Europe's technology research programs trace their roots to the early 1980s, when it became obvious that European high-tech industry was falling behind that of the United States and Japan. The EC was forbidden by its mandate simply to subsidize industry, so it took the tack of encouraging companies to become more competitive in world markets by pooling their research efforts. This was done by sponsoring "precompetitive" collaborative research: aimed not toward producing a particular product, but the underlying technologies required. Another aim was to draft in the expertise of academic researchers. In Europe, where most universities are state-funded, industry-academia links were not strong. In the new programs, project consortia were encouraged to draw university and government research groups into their fold.

Esprit was launched along these lines in February 1984 and has served as the model for a suite of other programs: RACE, which covers communications technology; BRITE/EURAM, covering materials and manufacturing technology; TELEMATICS, covering data-exchange techniques in areas such as government, health care, and distance learning; and many others (see diagram on next page).

The fashion for Europe-wide collaborations became infectious. In 1985, another research program, called Eureka, sprang up outside the EC. Eureka has a much more decentralized, bottom-up approach, says Kim Ruberg, the program's spokesperson, and it complements the EC's efforts by concentrating more on product R&D. With a staff of just 15 at its central office in Brussels, it acts as a marriage broker, putting research groups into contact with suitable partners in other member countries. The project partners then seek funds direct from their own governments; on average, about one-third of Eureka research funds come from the governments of its 20 member countries or from the EC. Its biggest project is JESSI, a $4.6 billion, 8-year effort to develop techniques for producing future processors and memory chips.

As the late-night proposal-writing indicates, Europe's high-tech programs are a major magnet for researchers. Esprit, for example, is always oversubscribed. The last call for proposals in 1991 drew 1300 applications; only 300 received funding. Compared to the



Networking. Europe's multibillion-dollar industrial research effort. (1 ECU = $1.21)

electronics industry's own spending, however, the amount of money involved is not huge: In Esprit's current 5-year phase from 1990 to 1994, it has a budget of about $1.8 billion. The amount awarded from this pot to Europe's largest electronics companies amounts to only about 2% of their own R&D spending on information technology. "We are not involved in these projects [just] because subsidies are involved," says Marino Carasso, managing director of the central research labs of Philips, the Dutch electronics giant based in Eindhoven.

What does draw big companies like Philips is the opportunity to forge links with other companies' research programs. "Before [Esprit] I knew my colleagues in the United States better than my colleagues in Europe. That has changed," says Carasso. "It's a real achievement," adds Michael Clark, assistant director at the Hirst Research Centre in London, part of the British electronics company GEC. "There's a new relationship between companies at all levels that didn't exist before."

Fostering a spirit of cooperation is all very well, but politicians tend to judge expenditures on more tangible results. Supporters of Europe's industrial research efforts can list some successes. Esprit, for example, helped Acorn develop the ARM processor—the power behind Apple's Newton hand-held computer—and the program also assisted Britain's Inmos in developing the transputer, a widely used parallel processing chip. But critics can point to projects that did not go according to plan—the effort to develop a European high-definition TV system being perhaps the most conspicuous (see box).

Although largely a technical success, the programs have not worked miracles for European high-tech industry. Europe's balance of trade in information technology and communications products fell from about zero in 1978 to a deficit of $40 billion in 1991. And as the continent dipped into economic recession in the 1990s, politicians and industrialists were beginning to wonder if they were getting value for their research money.

Early last year, the EC invited a panel of industrialists, led by Wisse Dekker, head of Philips' supervisory board, to review Esprit, RACE, and DRIVE (the part of TELEMATICS aimed at improving the safety and efficiency of road transport). The panel praised the projects' technical achievements, but said the grand vision of global competi-

HDTV: A Cautionary Tale

Any government considering supporting a high-technology strategic industry should consider the story of the mammoth effort to provide the couch potatoes of Europe with widescreen, high-definition television (HDTV). It is a tale with a simple moral: Getting the technology right is only a small part of the battle.

Europe's electronics industry panicked in 1986 when the United States suggested adopting Japan's nascent HDTV system as a world standard. Fearing that such a move would put Europe at a competitive disadvantage, the industry adopted a clever strategy: Develop a European HDTV system, based on satellite-to-home transmissions, using European technology that could be phased in gradually without making older technology obsolete. First, encourage the development of satellite TV broadcasts using a new transmission standard called MAC. Later, when new HDTV sets are ready, switch to a new high-definition signal called HD-MAC, which will also work with ordinary MAC sets at normal resolution. Sixty companies and research groups joined together in a Eureka project to develop the necessary technology, and European governments footed half the $750 million bill.

The key to this strategy was a directive issued by the European Commission in 1986 forbidding broadcasters from transmitting high-powered TV signals straight to people's homes in anything other than MAC. Broadcasts in MAC could either be picked up by a satellite receiver fitted with a MAC decoder chip or fed through to a purpose-built MAC TV set. Either way, direct broadcasting had to await volume production of MAC chips, and broadcasters began to get impatient. Led by Australian media mogul Rupert Murdoch, they soon found a loophole in the EC's MAC directive: It covered only high-powered satellites. Broadcasters could still use medium-powered telecommunications satellites to beam to small dish aerials using the current European TV system, called PAL.

Murdoch leased channels on the Luxembourg-owned Astra satellite and launched Sky TV in 1989, broadcasting in PAL. MAC TV sets went into volume production in 1990 but failed to catch on as broadcasters stuck with PAL.

As the planned switch to MAC got derailed, the next step, to HD-MAC, has also been set back. Many in the broadcasting industry are now arguing that all-digital HDTV transmissions are the way to go, and they believe Europe should not rush into HDTV production until digital systems are developed—probably toward the end of the decade. That leaves Philips, one of the lead companies in the Eureka HDTV project, stuck in a chicken-and-egg situation: It will not produce HDTV sets until broadcasters announce plans to make programs in HD-MAC. But what broadcaster will make programs that no one can watch? "No significant market has yet been shown for HDTV," says John Forrest, chief executive of Britain's National Transcommunication Limited. "It was misguided to drive HDTV into the market."

But the industry is putting on a brave face. Innovations spun off the HDTV project, such as digital sound and improved screens, have already enhanced conventional TV sets. And the expertise Philips and the French company Thomson have gained has made them major players in the consortia developing digital HDTV both in Europe and in the United States. Eventually, they hope their investments will pay off, but it will have been a long wait.

–D.C.

tiveness had not been achieved, says John Forrest, chief executive of Britain's National Transcommunication Limited (NTL) and a panel member. "Esprit results have tended to remain in the preserve of R&D departments, often leaving the rest of the company and especially top management in ignorance of what has been achieved," the report said.

The panel recommended a complete overhaul of the EC's programs. Esprit and RACE should be replaced with a program divided into a few areas that have precise, easily understandable goals, such as redesigning Europe's air traffic-control system. Unlike most existing EC collaborations, made up of companies with similar skills, projects in the new program would be "vertically integrated." Participants would include basic researchers, development teams, manufacturing experts, and even end-users of the technology.

Similar calls for change came from a survey last year of reactions to Esprit among the top dozen or so European electronics companies conducted by Jens Moritz, a senior director in the R&D department of Siemens, Germany's electronics giant. His report concluded that "a new program should continue the trend towards applications, in particular bringing users and suppliers together in projects driven by application." A planning task force assembled last year by the EC, and chaired by Hans Günther Danielmeyer, head of research at Siemens, joined in the chorus. "The role of technology users needs to be increased....It is essential for global competitiveness to think and to organize 'vertically integrated,' " its report said.

NTL's Forrest says that the EC's response to his panel's proposals has been a "deadly silence." One reason is probably inertia, but that may change. In January, the EC research commissioner, Filippo Pandolfi, departed, and research into information technology and communications was transferred to industry commissioner Bangemann. One of his first moves has been to shift the whole Esprit project into the directorate responsible for industry. The goal: to improve links with potential end-users of high-tech research.

Already, the guidelines provided in the latest call for proposals asked for tight, well-focused projects with vertically integrated partners. And Esprit officials say there will be more emphasis on clusters of projects working toward a well-defined aim. One model is the 20-project Open Microprocessors Initiative launched last year, and others are planned in liquid-crystal displays and high-performance computing.

Europe's industrial researchers have had a lot of fun pursuing interesting topics they might not otherwise have been able to without help from Brussels. But the new message, says one EC official, is: "Stop playing, now it's for real."

–Daniel Clery

CHEMISTRY

European Elites Envy American Cohesion

CAMBRIDGE, UK—Ask a dozen of Europe's top chemists how European chemistry is faring and where the hot research groups are, and you'll get a dozen different answers. But try asking them the same questions toward the end of March and you are likely to get no answers at all, because many of Europe's chemistry elite will be on the other side of the Atlantic, at the American Chemical Society's (ACS) spring meeting. The diversity of responses—and the nonresponses during March—say a lot about the state of chemistry in Europe.

European chemistry has a distinguished history, helped by the fact that eight of the 10 largest chemical companies in the world are based on the continent and have pumped hundreds of millions of dollars into their own and university labs over the years. And many of Europe's leading chemists express optimism when asked about the future of the discipline. Take University of Birmingham organic chemist Fraser Stoddart, who is working in one of the hottest fields, self-assembling molecules: "Chemistry is doing exceptionally well in Europe," he says. Or listen to Dieter Seebach of the Swiss Federal Institute of Technology: "Europe," he says, "is doing excellently compared with both the United States and Japan."

There's some evidence to back up those impressions. Europeans have carried off 23 of the 55 the Nobel Prizes for chemistry awarded since 1960.* And European groups including those led by Harry Kroto at Sussex University and Wolfgang Krätschmer at the Max Planck Institute of Nuclear Physics in Heidelberg, helped establish the fast-moving field of buckyball chemistry. But the jewels of European chemistry are scattered widely across the continent. "We see excellence in particular fields in laboratories all over Europe," says Nobel Prize–winner Jean-Marie Lehn, whose own lab at the University Louis Pasteur in Strasbourg is at the forefront of self-assembling molecules. "It is difficult to say [what Europeans do best] because research is so varied," he adds.

One reason European chemistry is fragmented is that there's no central funding body like the U.S. National Science Foundation to focus money on the top labs. There are few major European centers of excellence in basic research—of the likes of Caltech, Berkeley, and the Massachusetts Institute of Technology—that are strong across most subdisciplines of chemistry. Instead, each country has its own national research bodies that spread resources around dozens of labs. And there's no European equivalent of the ACS to provide a continent-wide sense of community, nor a European chemistry journal.

*1962: John Kendrew and Max Perutz (UK); 1963: Giulio Natta (Italy) and Karl Ziegler (Germany); 1964: Dorothy Hodgkin (UK); 1967: Manfred Eigen (Germany) and Ronald Norrish and George Porter (UK); 1969 Derek Barton (UK) and Odd Hassel (Norway); 1973: Ernst Otto Fischer (Germany) and Geoffrey Wilkinson (UK); 1975: Vladimir Prelog (Switzerland); 1977: Ilya Prigogine (Belgium); 1978: Peter Mitchell (UK); 1979: George Wittig (Germany); 1980: Frederick Sanger (UK); 1982: Aaron Klug (UK); 1987: Jean-Marie Lehn (France); 1988: Johann Diesenhofer, Robert Huber, and Hartmut Michel (Germany); Richard Ernst (Switzerland). In addition, Australian John Cornforth (1975) spent his entire career in the United Kingdom.

Country Scorecard

Rank	Nation	Papers	Nation	Cites/paper
1	USA	94,237	USA	4.47
2	USSR	47,870	Israel	4.01
3	Japan	42,229	Switzerland	3.92
4	Germany*	36,859	Netherlands	3.48
5	United Kingdom	26,685	Canada	3.37
6	France	21,342	Sweden	3.36
7	India	15,719	Denmark	3.11
8	Canada	13,430	United Kingdom	3.00
9	Italy	12,508	Australia	2.98
10	Spain	10,566	New Zealand	2.96
11	Poland	8408	Ireland	2.94
12	Netherlands	6872	France	2.88
13	Peo. Rep. China	6178	Germany*	2.87
14	Australia	5716	Hong Kong	2.80
15	Czechoslovakia	5681	Italy	2.75
16	Switzerland	5197	Japan	2.64
17	Sweden	4440	Austria	2.51
18	Hungary	3570	Belgium	2.32
19	Belgium	3316	Norway	2.22
20	Egypt	3067	Greece	2.13

*The listings for Germany include the papers and citations of the German Democratic Republic and the Federal Republic of Germany together. The paper and citations per paper for each, 1981–91, are as follows: F.R.G. 23,547 papers, 4.01 citations per paper; G.D.R. 5,389 papers and 1.60 citations per paper.