Science and technology in France

Increases of the civil R&D budget of nearly 20% per year, new links between science and industry and more involvement of scientists in research policy constitute an experiment to revitalize French science and industry and the nation's economy.

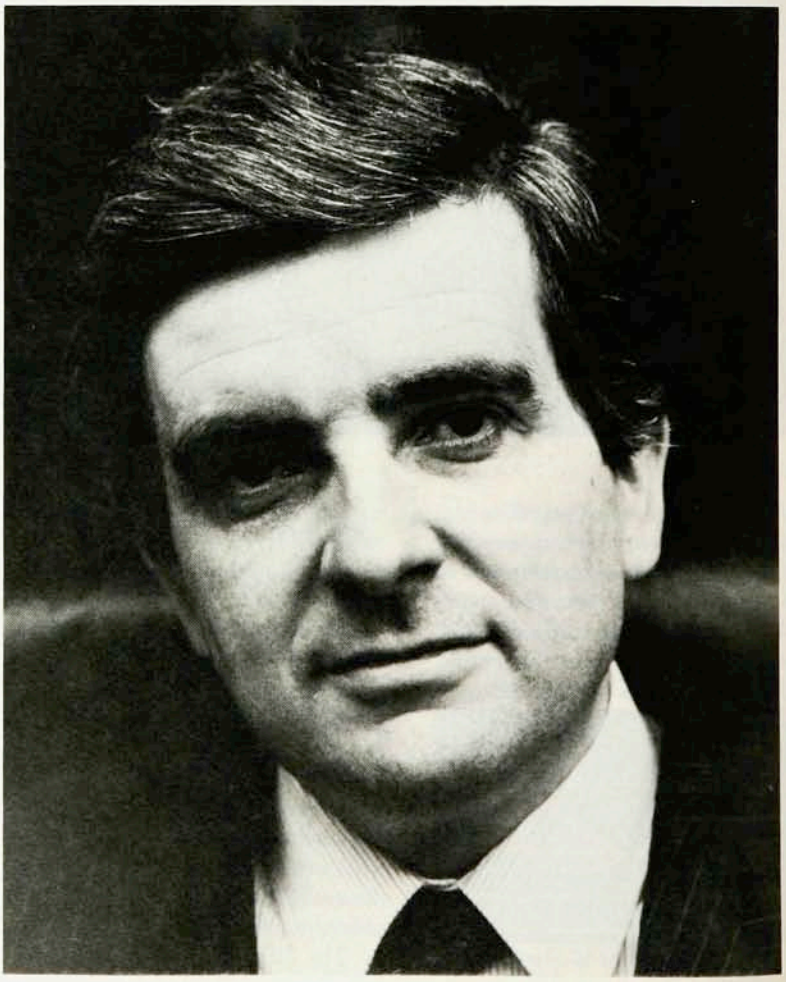
Abraham S. Friedman

Jean-Pierre Chevènement had a bold plan: to bolster the French economy by envigorating science and technology. As the first head of the new French Super Ministry of Research and Industry, this brilliant young socialist sought to create new jobs—especially in high-technology production—by making French companies internationally competitive.

He started by restructuring the French science establishment. He engineered new routes between government scientists and industry: *les grands organismes*—the government research bodies—are now able to form profitable liaisons with industry. There are new links between education and research, as the *grandes écoles*—the elite universities that train managers—begin to provide more research themselves. In fact, the task of the research labs and their scientists has now expanded to include the training of researchers and the publicizing of discoveries. Chevènement did not stop there; he tried to bring more democracy into science by communicating more about scientific developments to the public and, significantly, by giving researchers more influence over government and laboratory policy.

Past and present

Following the recent municipal elections in France, in which the government coalition candidates—and particularly the communists and the far left—lost ground, Chevènement was replaced by Laurent Fabius, who had been Minister of the Budget and became Minister of Industry and Research. (Now "industry" precedes "research" in the Ministry name.) It seems likely, however, that Chevènement's policies will continue to be followed by his successor. In fact, many of these policies had been suggested by Chevènement's predecessors in the Giscard administration. In the latter years of the Giscard Administration, Minister of Research Pierre Aigrain attempted to give the regional research centers some independence from Paris. These research laboratories of the National Center for Scientific Research (CNRS), the Atomic Energy Commission, the Agriculture Ministry, and so forth, are scattered throughout the provinces and their programs and their budgets have been determined by their parent agencies in Paris. Aigrain also tried to increase interaction between government research scientists and industry by encouraging mo-



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bility of scientists and engineers. One means he chose was sharply criticized by much of the scientific community: To encourage government scientists to gain experience in other laboratories or in industry, he made transfers a condition for advancement. Aigrain, who studied at Carnegie Tech, taught at MIT and worked in industry, readily recognized the value of cross-fertilization between government and university scientists and their industrial colleagues.

During the Giscard Administration, Minister of Industry André Giraud instituted an ambitious, innovative and controversial nuclear-power program. He increased reliance on light-water reactors (for a while, one new 900-MW reactor was coming on line *every eight weeks*), instituted an aggressive program to develop indigenous breeder reactors and expanded the French nuclear-fuel reprocessing plant at La Hague (to quadruple its capacity in less than a decade), using the most advanced technology.

In May 1981 the Mitterrand Administration came into power and Chevènement was named Minister of Research and Technology. Chevènement soon called for a series of regional and then national colloquia on science and technology, to be attended not only by scientists and technicians but also by representatives of industry, civic associations, academia and trade unions. The colloquia set priorities in science and assessed the potential role of science in improving the French economy. He initiated another series of regional meetings, followed by a parliamentary review, to make recommendations on the French nuclear-power program. The legislation that resulted was the Science Program Law, which the National Assembly passed in July 1982.

Chevènement and Fabius. Jean-Pierre Chevènement (opposite) was the first head of the Ministry of Research and Industry; his successor is Laurent Fabius (below), present head of the renamed Ministry of Industry and Research.

With the support of both reviews, Chevènement and the new French Administration continued the ambitious nuclear-energy program begun by Giraud and adopted many of the reforms initiated by Aigrain. Further, they went on to change the relationships between scientific practice, science education, and industry.

Science and industry

When the Mitterand Government subsequently created the new Superministry of Research and Industry, it formally sanctioned a close relationship between science and industry. The new ministry combines the old Ministry of Research and Technology and the Ministry of Industry. It also includes within its single jurisdiction agencies previously under the ministries of health, agriculture and education. For example, the CNRS (which resembles the NSF but also has its own laboratories and regional centers), formerly within the Ministry of Education, is now part of the new Super Ministry. Also within it is a vast array of technical agencies and research bodies. Among the most important are the Atomic Energy Commission (CEA), the National Center for Space Studies (CNES), the National Center for Ocean Exploitation (CNEXO), the National Research Institute for Computer Science and Automation (INRIA), the National Agency for the Valorization of Research (ANVAR), which supports the industrial development of ideas discovered in government and university laboratories, and the Bureau of Geological and Mining Research (BRGM).

In addition, the Minister of Research and Industry oversees the budgets and programs of a number of other ministries with large research institutes: the Ministry of Agriculture's National Agricultural Research Institute (INRA), the Ministry of Health's National Institute for Health and Medical Research (INSERM) and the Ministry of Housing and Urban Development's Scientific and Technical Center for the Building Industry (CSTB).

Nationalized companies, even private ones, also feel the influence of the government over matters of policy. Some of the larger technical agencies within the Government have technical companies as subsidiaries, and some of these subsidiaries are shareholders in private companies. In a few key industries, the government has nationalized companies so it can coordinate R&D efforts to prevent duplication and can get industry to spend more on R&D. The result is that it is often difficult to

determine the degree of governmental control over a company or in an industry. For example, the nuclear-fuel-cycle company COGEMA is a fully-owned subsidiary of the Atomic Energy Commission. In turn, COGEMA directly owns controlling interest in the multinational uranium-enrichment company EURODIF, and it shares with recently nationalized Pechiney-Ugine Kuhlmann (PUK), control of the uranium conversion companies COMURHEX and SIMO.

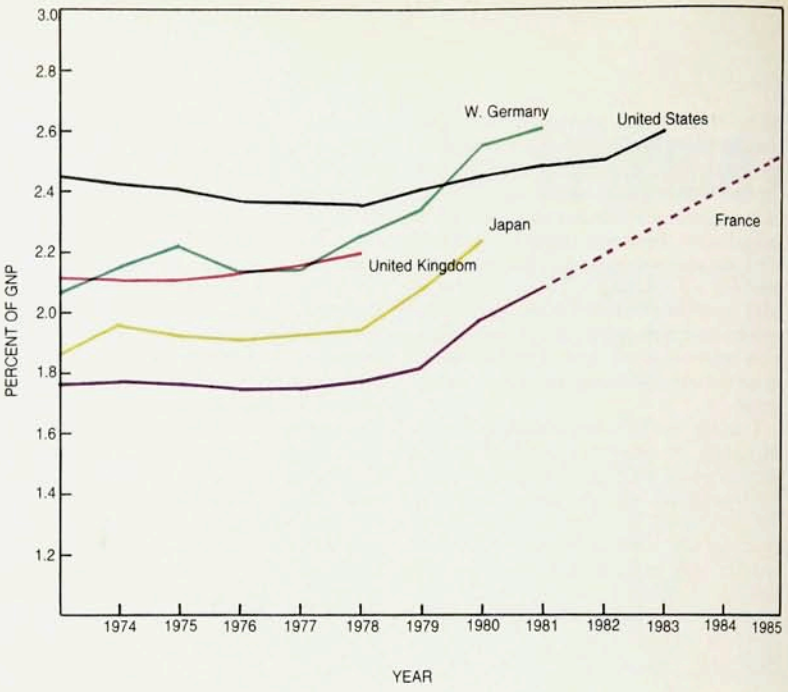
Larger R&D budgets. The Mitterand Administration is significantly increasing research support in France. The new Science Program Law commits the government to specified increases in funding and staffing for the national research centers over a five-year period; it also aims at assuring a balance between fundamental and applied research. It provides for annual increases of 17.8% (in real terms) in the civil R&D budget through 1985 as well as technical staff increases of 4.5% annually. In 1982, science funding was increased 29.6% over 1981, and staffing of government laboratories went up with an even more impressive increase of 37.1%. Increases in private-industry support of research by 8% a year are also anticipated. Overall support of research is planned to reach 2.5% of GNP in 1985—currently it runs about 1.8%, with 0.8% from industrial research support. With this planned 2.5% for R&D, French spending will be in proportion to US, German and Japanese science funding.

Part of the government money is going to incentives to encourage research in private industry. The National Agency for the Valorization of Research provides grants and loans at low rates of interest to encourage industries to increase their research budgets and to cover the costs of introducing innovative technologies. In 1981, about 1500 firms were receiving ANVAR assistance; that number will probably go up to 5000 in the near future. Following Chevènement's visit to the US in September 1982 (which included visits to several high-tech firms in the Boston area), he proposed a law permitting tax exemptions for research expenses—an incentive that French industry had not benefitted from in the past.

Nuclear energy

While the current administration is encouraging research in solar and geothermal energy, the previous administration's ambitious nuclear power program continues to be supported and is still expanding rapidly. The 1200-MW Super Phénix breeder reactor is being completed on schedule (it should begin to operate in early 1984); and the expansion of the La Hague reprocessing plant has been approved. Framatome, the French nuclear-power-plant construction company, is now starting to build 1300-MW pressurized water reactors for EDF, the national electricity utility, and has been completing its series of 900-MW pressurized water reactors at a rapid rate. Twenty-four 900-MW PWRs are currently supplying electricity to the national grid, in addition to six old gas-cooled graphite-moderated reactors, one small heavy-water–gas reactor, one 300-MW PWR and the Phénix demonstration breeder reactor at Marcoule. Of the twenty-five reactors currently under construction, twelve are 900-MW PWRs, twelve are 1300-MW PWRs, and one is the 1200-MW LMFBR Super Phénix. Finally, construction is starting on one 900-MW PWR, and five 1300-MW PWRs are to be authorized over the next two years. The French nuclear power plants in operation, under construction and planned, are shown in the figure on page 28.

The new French government has also authorized the expansion of the La Hague fuel-reprocessing facilities. It has, however, deferred any decision on additional large commercial breeder-reactor construction until after the Super Phénix has operated for some time.



Domestic research and development by year as a percentage of gross national product. (Information provided by the Organization for Economic Cooperation and Development.)

Diffusion of science and technology

Another objective of the Science Program Law is the encouragement of diffusion of science and technology. A new technology assessment office, with scientists and representatives from industry and trade unions on the staff, will advise members of Parliament on scientific matters. The use of the French language will be increased in scientific publication, with the hope of making research results more accessible to industry and the public. *Boutiques des sciences*, local science centers, are being set up to inform the public about scientific issues. There is to be a program of research on the effects of new technology and on the improvement of working conditions, and there are plans to perform research in cooperation with countries of the Third World.

When the French talk of better diffusion of science and technology, they are also referring to the importation of technology from other countries to France. Thus, an active and effective program to obtain information on new technological developments in the US has been under way for a number of years. The US has science attachés or counselors in US embassies in nineteen countries and in five missions to international organizations; most of these offices are staffed by a single person. France, on the other hand, has in the United States alone a scientific mission in Washington with at least six scientists and engineers, each an expert in a particular field (geology, space science, computer engineering, biomedical

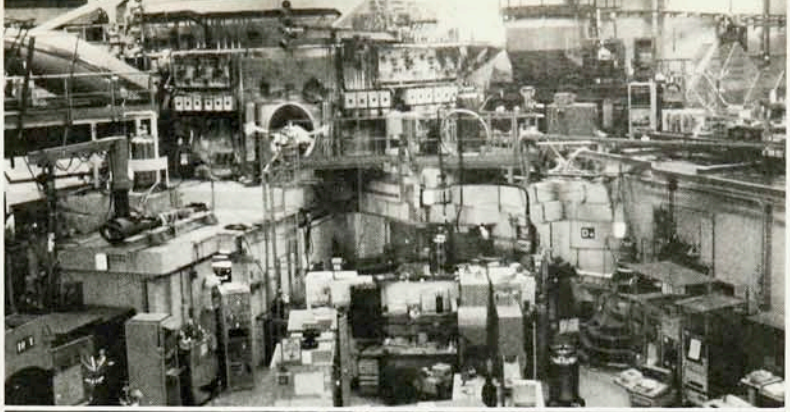
science, hydraulic engineering and aeronautic engineering), as well as science attachés stationed in Chicago, New York, Houston, San Francisco, Los Angeles and Boston. In addition, about twenty young scientists, "coöperants," are working for French Science Missions in lieu of military service. Several French technical agencies and national companies—The Atomic Energy Commission, CNRS, ANVAR and COGEMA, for example—have their own representatives in the US.

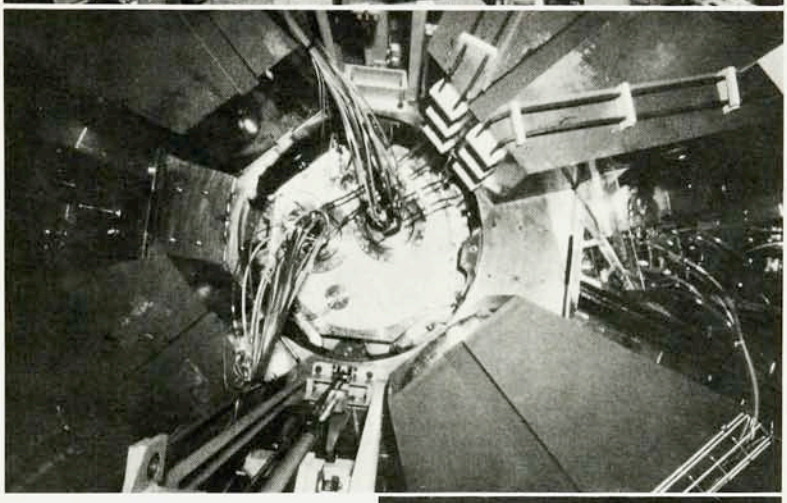
French industry is, in general, favorable to the goals of the Administration's science policy. At a meeting in early 1982, the members of the "Patronat" (the Association of French Employers and Manufacturers) noted their approval of the Government's goal to increase research expenditures from 1.8 to 2.5% of GNP. They are concerned, however, about the increased bureaucracy created to reach these goals. (Incidentally, one-quarter of employed adults in France work for the Government or nationalized industries.) The Patronat proposed improvements in science and engineering education to supplement the government's planned increases in the enrollment in engineering schools and in the number of science graduates. They proposed additional measures to increase the mobility of scientists and engineers between the public and private domains. They approve the government support of both basic and applied research through financial incentives and the use of its tax breaks for their research expenditures. Finally, they stress the need to develop markets to support industrial research.

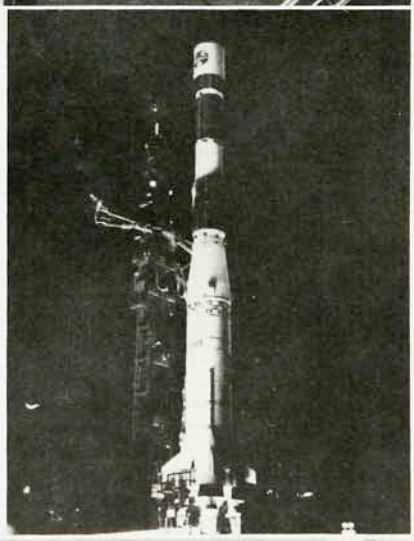
The Mitterand Administration, aware of its inability to make significant and rapid advances in all sectors of technology at once, has concentrated its efforts and assistance in a few high-technology fields where it believes it may see major improvements before long. Thus, a major push is being given to what are called "mobilizing" programs, the most important of which are biotechnology, new energies, robotics and electronics. In addition, a number of large technical programs already well along continue to get special attention; these include nuclear power, space, aeronautics, and ocean resource development.

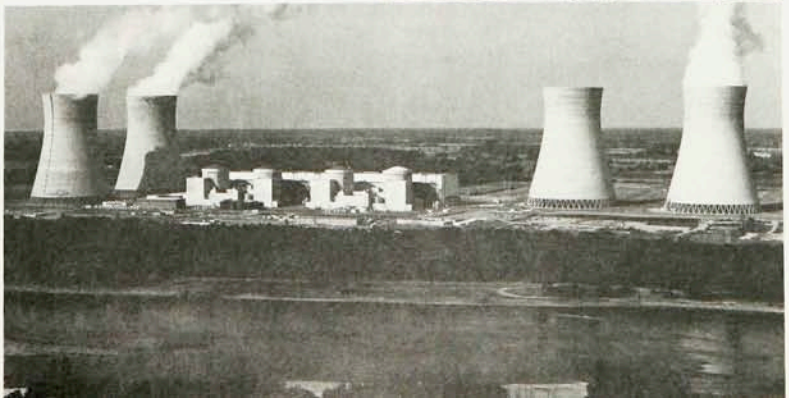
Electronics

To illustrate the French government's role in support of industry, consider the electronics industry as an example. In July 1982 the French Council of Ministers (Cabinet) approved a program of massive government support to increase French capabilities in electronics. The program aims to develop an indigenous electronics industry capable of competing in the

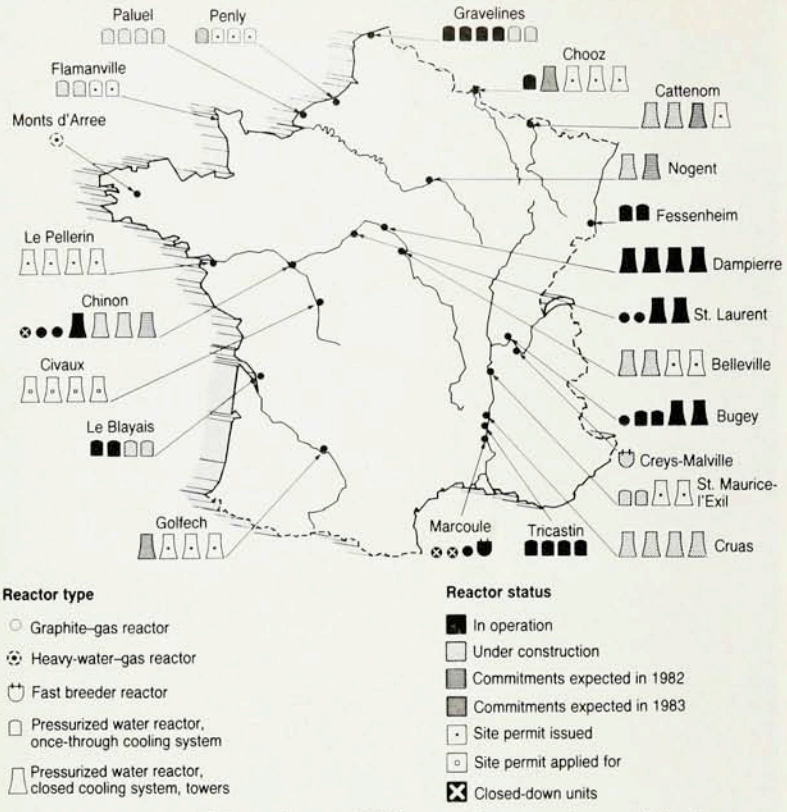








Four recent achievements of French science: top, the assembly for guiding low-temperature neutrons at the Institut Laue-Langevin (photo from CNRS); above, the four magnets of the CSS2 accelerator, seen from beneath the heavy-ion accelerator GANIL (photo from CNRS); right, the launching of Ariane (photo from CNES/CSG); below, the Dampierre nuclear reactor in Burly (photo from EDF).



Nuclear power plants in France, January 1983, by type of reactor and status of planning or construction. (Information provided by the French Atomic Energy Commission.)

world markets to reduce French reliance on electronic equipment and technology that it currently must purchase from abroad, and to create jobs both in the electronics industry itself and in other industrial sectors dependent on the electronics industry. A government study concluded that without government support, the industry will show a trade deficit of Fr. 19 billion (about $2.7 billion at 7 francs/dollar) by 1986 and a significant loss of jobs. The industry currently employs 318 000 people; the new government support program aims at creating 80 000 additional jobs in this sector. Proposed financing from government and other sources for this program amounts to Fr. 140 billion ($20 billion) over a period of five years for the entire electronics industry.

A first estimate has a portion of the Fr. 140 billion distributed as follows:

- ▶ electronic components (Fr. 10 billion)
- ▶ consumer electronics (Fr. 7 billion)
- ▶ office machines (Fr. 2 billion)
- ▶ software and services (Fr. 4.5 billion)
- ▶ industrial computers and automation (Fr. 3 billion)
- ▶ space industry (Fr. 15 billion)
- ▶ professional electronics, military and civilian (Fr. 25 billion)
- ▶ scientific and measuring instruments (Fr. 2 billion)
- ▶ medical electronics (Fr. 3 billion)

I should note that in the current serious recession France is suffering, the ability of the government to fulfill its financial commitment to the electronics industry is in great doubt. The most assured support will go to the big nationalized industries and to small and medium-sized private enterprises specializing in microelectronics. It is interesting, that aside from those in banking, most major nationalizations occurred in the high-technology industries. The six big industries recently nationalized are Thompson, Rhone-Poulenc, CII-Honeywell-Bull, Saint-Gobain, Compagnie Generale d'Electricité (CGE) and Pechney-Ugine-Kuhlmann (PUK). In addition, a large number of important high-tech companies are semi-public—that is, the government has significant shareholdings (and hence some degree of control). Examples of such semi-public companies are Matra, Empain-Schneider and Framatome.

At the present time, the government has neither defined the means by which it will allocate financial support to the electronics companies nor indicated which activities in each of the companies it will support. In general, however, the Council of Ministers has indicated several principal areas of activity.

- ▶ Training and education. The National Education Ministry and the Ministry of Vocational Training plan to institute new basic-technology training programs and accelerated courses to produce more than 7000 engineers and technicians by 1985.
- ▶ Improved coordination between national research laboratories and industry. Government laboratories are to devote more effort to research and development programs that can contribute to the electronics industries in such areas as computer-aided design for highly integrated circuits, engineering software using artificial intelligence, computer graphics, basic modules for minicomputers and large computers, computers for use in education and training, and consumer electronics.
- ▶ Industrial policy. To eliminate competition among French electronics firms, the government intends to allocate particular segments of the electronics expansion program to particular principal French high-tech manufacturers. For example, the production of videorecorders will be turned over to Thomson, which is to produce a million units annually by 1986. The goal is to increase the French share of the world color-television market from 5 to 9 percent.

In the area of office electronics—including photocopying machines, electronic typewriters and printers—France would like to become one of the European leaders. At the present time, these components are responsible for a deficit of Fr. 2 billion per year. For 1986, the Ministry of Research and Industry predicts a positive trade balance; the main producers in this field will be Matra and Thomson.

In informatics and data processing, CII–Honeywell-Bull is to play the major role, especially for medium-sized computers; in telephone development, Compagnie Generale d'Electricité will be involved.

It is too early to say whether success will follow from the new directions of French science: the coupling of science and technology to industry, advancing technology and assisting high-tech industry. It will take years for the programs to produce the results desired: making French industry more competitive in world markets, creating jobs at home, and redressing the trade imbalance. The effects, no doubt, will be closely watched by developed countries around the world.

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This article is based on a talk given at the annual meeting of the AIP Corporate Associates at Sandia Laboratories in October 1982. □