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# National Planning of Science and Technology in France

France develops a national science policy through cooperation of government, industry, and scientists.

James Brian Quinn

France is in the midst of an imaginative and dynamic experiment in the planning of civil science and technology (S&T) on a national scale. France has the most formalized structure for national planning in the Western world, and many countries expect her to lead in developing useful new concepts and techniques for integrating science and technology into national plans. French efforts and progress in this regard deserve the attention of thoughtful scientists and national policymakers throughout the world.

## Planning: An Orderly Technique

What France is attempting to develop is an orderly technique for making essential decisions about science and technology. Increasingly the nation has realized that there is no major sphere of national policy which is unaffected by science and technology. Economic and fiscal policies must be tailored to the country's capacity to compete internationally and to provide ever higher domestic living standards. Defense and foreign policies depend on the country's technological and economic strength. And rational policies for agriculture, health, welfare, and education must reflect the present and future potential of modern science and technology. Recognizing this, the French are trying to develop organized ways to include "science in national policy" and to establish "national policies for science" (*1*). On the one hand they are attempting to analyze the potential effects of science and technology on various national affairs and to provide for scientific advice at proper levels throughout their policy-formulation structure. On the other, they are trying: (i) to allocate their limited scientific and technical resources to achieve maximum support for France's entire complex of national goals, and (ii) to advance the health of their scientific and technical communities by providing sufficient resources both for adequate academic training and for active pursuit of research and development in areas of vital national interest.

The alternative to planning scientific and technical commitments is not, as many initially believe, to leave S&T in a wondrously free state, uninvolved in political or economic affairs, for government and the economic community must make decisions which are affected by—or which actively influence—science and technology. In France, the government must build and staff educational and research institutions. It must maintain a viable military establishment to support international goals. Through its nationalized industries, the government must also determine what technologies will be used for transportation, energy conversion, and communications. In most other fields private decisions determine the nation's technology, that is, the nature of its producing units, the sophistication of its industrial processes, the variety of its products, and the raw materials and human skills

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which will be exploited for economic purposes. Such decisions must be made in any modern nation, with or without national planning. Thus, the true alternative to planning in this sphere is to allow independent decisions simply to lead wherever they will.

During the postwar period a powerful group of intellectuals and political pragmatists began to believe that France could not afford the potential conflict and waste of completely uncoordinated S&T commitments. The country's pool of trained scientific and technical people was too small (approximately 40,000 scientists and engineers in 1963) and too vital to national interests to allow for avoidable wastes. In the late 1950's the government unilaterally began a first step toward more effective use of S&T resources. It developed an improved apparatus to analyze and coordinate its own commitments in order to avoid waste, duplication, or inadequate support for specific scientific areas or technological programs. This amount of S&T "planning" is the minimum obligation of any responsible government.

But the French soon realized that the S&T decisions of the private sector were intimately intertwined with those of government. Both competed for the same technical personnel. (Approximately 17,000—or over 40 percent—of France's scientists and engineers were in industry in 1963.) Agriculture, service activities, and industry had to be kept technologically efficient to provide a strong economic base for the country. And private industry had to provide components, equipment, and raw materials to permit truly effective development of the government's own S&T activities.

Consequently, the government set up a dialogue with the private sector on scientific and technical affairs. This dialogue offers the private sector information about the government's desires and intentions. Similarly, it provides an organized means for the private sector to inform the government about its plans and needs. As a result of this dialogue the government hopes that it and industry will be able to make key decisions on civilian science and technology in a coordinated, balanced way to support all major national goals. It is this aspect of France's S&T planning which represents the most radical departure for a "private enterprise" economy of the Western world, and it is on this aspect of French planning that this article will focus.

## The Planning Philosophy

The inclusion of private S&T in national planning is completely compatible with the French concept of "planning without compulsion." Those involved in planning constantly emphasize their intention to avoid "central direction" of science or of the total economy. The basic philosophy of French S&T planning is to bring the proper people together in an orderly way to help make the decisions they should probably influence anyway. The result of the process is not "direction" of S&T by a central authority, but an attempt to rationally allocate limited resources in both private and public spheres. The chief technical officer of an international pharmaceutical company expressed the French planning philosophy succinctly as follows:

> The Plan does not tell a private research organization what to do. Nor does it tell a company what it is to sell. On the other hand, reports from the Plan say, "If we want to reach particular economic goals . . . there is need for research on the following items." It does not divide up the specific projects to be accomplished by different institutions . . . The government will not contribute monies to private companies' research efforts. And industry would not follow the Plan in areas which did not interest it.

However, the government clearly has incentives it can use to encourage actions compatible with its policies and to discourage those conflicting with its wishes. The government, of course, will invest directly only in scientific and technical efforts compatible with its specific objectives. It can manipulate general financial and credit policies to support its ends. It may also use tax credits, concessions, penalties, or subsidies to influence individual organizations. Licenses or permits can be made simple or difficult for individual concerns or economic sectors to obtain. Similarly, the ease with which a concern or economic sector can make sales to the government may depend upon its general cooperation with certain aspects of national policy. Yet such incentives and remedies are no different from those available to any other elected government. And they are not necessarily more dangerous with national planning than without it.

The only authoritarian enforcement measures now in use are building permits, authorizations to construct new plants in Paris, permits to open oil refineries, and certain price controls (*2*). On the other hand one should recognize that through nationalization the government has obtained substantial direct control over the important technological areas of energy, transportation, and telecommunications, which together account for a large percentage of France's total S&T investment. Some also claim that the government has used its control of commercial banks to extend or withhold credit to individual concerns on a discriminatory basis. But virtually all such direct controls are outgrowths of decisions to nationalize or subsidize certain industries and not results of national planning per se.

To effectively develop and allocate science and technology on a national basis it was vital that France satisfactorily balance its use of sanctions, voluntary cooperation, and the totally free choice of individuals. No one I met during my study thought that unreasonable authoritarian sanctions had been applied, and most thought that better planning had both strengthened French science and furthered the application of technology in the national interest. Interestingly, many French industrialists and scientists believe they are considerably freer from government interference than their U.S. counterparts. Many also state that the technical and business communities benefit substantially from having government investments, incentives, and sanctions applied within a carefully conceived overall framework, rather than as the result of a random interplay of political power among individual concerns, economic sectors, and government departments. The French planning process provides a formal mechanism for presenting and weighing the views of all competing interests. Hence it militates against unwise decisions which might draw unwarranted technical support or investment into certain politically popular fields despite overwhelming cost to other more important sectors.

The organizations which carry out this "noncoercive planning" concept are uniquely French. They have been designed to cope with the special problems currently facing France. They have been adapted to France's unique institutions of government, commerce, and education. Yet they are not ultimate solutions. They are constantly evolving to meet new needs and challenges. Hence they must not be judged by their direct transferability to other cultures, but by their success in helping France deal with its special problems in a changing world.

### The Interministerial Committee

The three most important bodies in the formulation and execution of science policy for the government sector were created by decrees on 28 and 29 November 1958. Figure 1 shows their relationship to each other and to other major scientific and technical planning groups (*3*).

The Interministerial Committee for Scientific and Technical Research consists of those cabinet members responsible for the principal research-performing groups within the government (*4*), along with the Minister of Finance and Economic Affairs. This committee, under the direct chairmanship of the Prime Minister, meets about twice a year to consider "all measures tending to develop scientific and technical research" as well as those concerned with "equipment programs and the apportionment of means and resources, particularly in relation to allocations to be made in the budgets of the different ministries concerned." The concerns of government scientific and technical research are thus brought to the highest possible political level for policy formulation and coordination.

### The Consultative Committee

The Consultative Committee for Scientific and Technical Research (popularly called the "Committee of Sages") consists of 12 scientists chosen for their particular competence in the physical sciences, technical research, or social sciences. They are chosen as individuals and not as representatives of particular disciplines, economic sectors, or organizations. They are appointed for 2-year terms, although in practice each man usually serves 4 years, with half the committee retiring every second year. This turnover, together with the relative youth of the committee members—none to date has been a member of the French Academy of Sciences at the time of his appointment—is intended to provide a constantly fresh and objective viewpoint.

The function of the Consultative Committee is the overall review of research carried out under government auspices. The committee makes recommendations on total government expenditures for R&D and the overall allocation of funds to the major government research organizations. But it does not try to influence expenditures on specific projects within organizations. It also advises the Interministerial Committee on scientific policy matters, such as international scientific cooperation, technical manpower and training needs, and incentives for science and technology. Major recommendations usually appear as approved reports or adopted motions. But the committee meets frequently (approximately biweekly), and "the government is aware of its discussions." Consequently, the government has an important mechanism for continuous high-level scientific advice. This committee was a new departure for France, intimately and formally involving scientists in top-level discussions of government policy formulation for the first time in French history.

### The General Delegation

The focal point for government staff work associated with technical and scientific planning is the General Delegation for Scientific and Technical Research (*5*). This body is the common secretariat for the Interministerial and Consultative committees and provides staff analyses for the Secretary of State for Scientific Research. It is also the clearinghouse for all scientific and research matters under the aegis of the General Planning Commissariat and, specifically, provides the secretariat of the "horizontal" Commission for Scientific and Technical Research. There are only about 100 full-time people in the General Delegation, but their capacities are vastly extended by the appointment of consultants and specialized work groups on particular topics. A member of the Delegation estimated that about 500 people currently participate directly in its activities, most cooperating part-time while employed full-time by private or government organizations.

In the formal review of government research programs the Interministerial Committee, Consultative Committee, and General Delegation operate like this. The General Delegation discusses R&D plans with top-level policy formulators and research-performing groups in the ministries while plans are in early formulation stages. The ministries then propose budgets which are consolidated by the General Delegation and forwarded to the Ministry of Finance for review with respect to the total funds available, but not for allocation to the individual ministries. After this the budgets, with analyses by the General Delegation, go to the Consultative Committee, which advises both on total S&T expenditures and on the distribution of government funds to various agencies. Next the recommended "*enveloppe*" goes to the Interministerial Committee, whose responsibility is to allocate funds by common criteria to each of the ministries and to insure that these allocations offer balanced support to the long-range goals of France. Normally the Interministerial Committee changes the total funds and allocations recommended by the Consultative Committee. The "new *enveloppe*" returns to the Consultative Committee for review and then goes back to the Interministerial Committee. This cycle continues, with further staff help from the General Delegation, until the Interministerial Committee is satisfied with the overall budgetary balance. The budgets then go to each minister for final commentary before submission to the National Assembly for approval. At all stages of budget preparation the General Delegation is said to join in the "dickering" and "negotiations" which are an integral part of any such process. Thus, the General Delegation plays an important role in coordinating the government's research commitments.

The General Delegation is also a key link in coordinating public and private R&D. Its National Inventory for the Means of Research studies French R&D resources in both the public and private sectors and analyzes questions of research organization and documentation. Its Funds for Development of Scientific and Technical Research support "concerted actions" which bring together scientists from different disciplines—and often different economic and social sectors—to work on problems of national importance. And, most important, its Planning Service provides all staff services on scientific and technical affairs for the General Planning Commissariat, advises on appointments to key planning committees for R&D, and actually prepares the major coordinating report on S&T for the French National Plan—the most important single vehicle for coordinating public and private research on a national scale.

### General Planning Commissariat

The General Planning Commissariat has actual responsibility for drawing up these 4-year National Plans, which cover all aspects of the economy. The Commissariat is a small government office

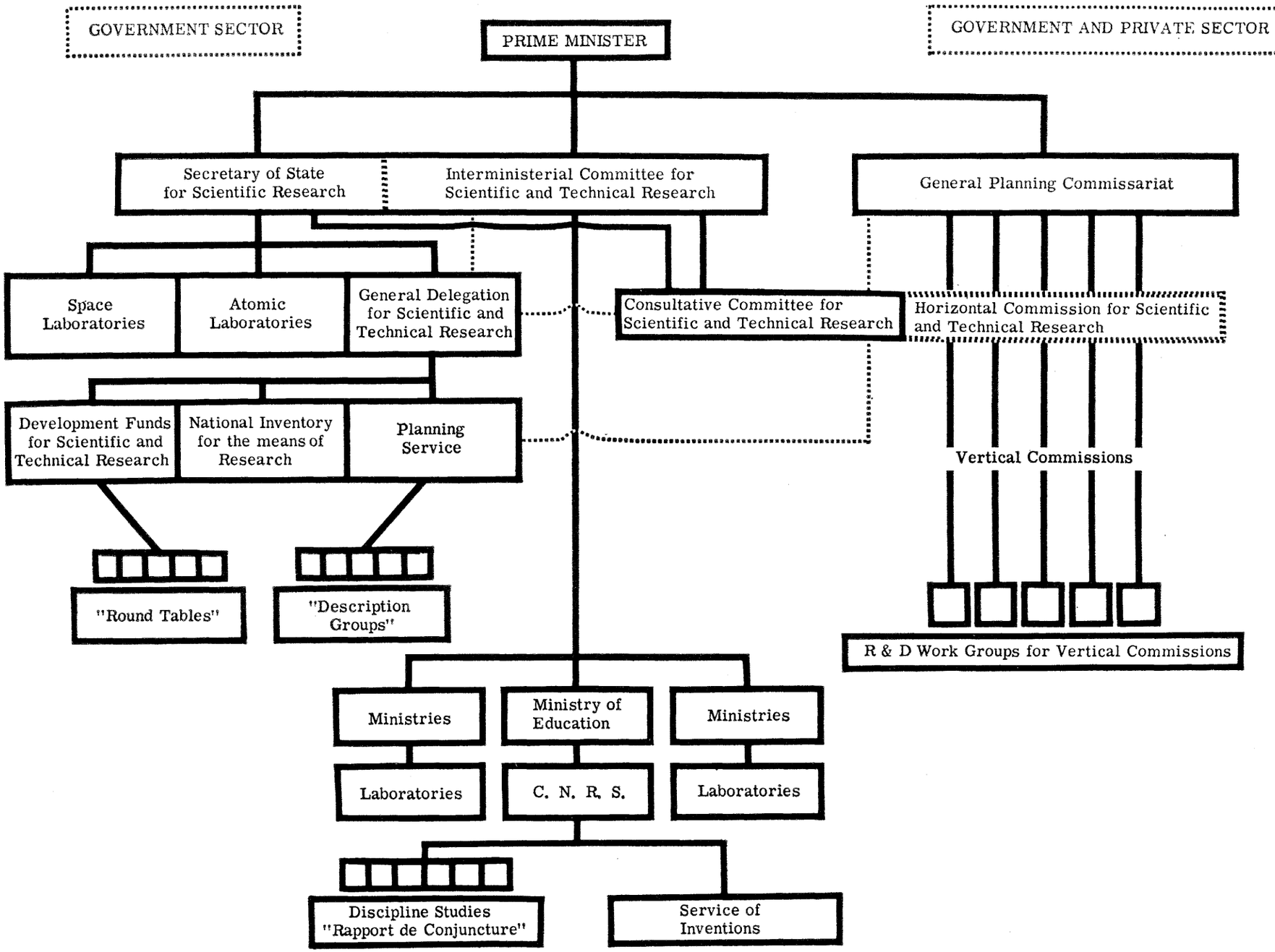


Fig. 1. Basic organizational relationships in French science planning (*3*).

containing a few hundred people. It has no authority to enforce cooperation during planning or compliance with an approved Plan. Instead the Plan is based on voluntary consultation among all sectors through a network of "commissions," appointed and coordinated by the Commissariat. Over 3500 people participate part-time on these planning commissions.

Central to the planning process are some 23 "vertical commissions" (*6*). Each carries the major burden of drawing up a plan for its "sector," that is, an important industry (Energy), economic area (Agriculture), or major social question (Health and Social Investment). Each vertical commission usually contains representatives of industry, government, and labor. Representatives are selected by the Planning Commissariat after consultation with appropriate business syndicates within the national employers' organization (Conseil National du Patronat Français), government administrators, labor unions, and so on. The Commissariat tries to select people who will work constructively with all others on their commission and to avoid those who would bog down the commission's activities in endless diatribes or who would not have the energy and interest to carry the load.

The first three national plans did not give much specific attention to the impact of science and technology. Some effort was made to introduce S&T factors into the Fourth Plan (1961–1964), but the final plan primarily reflected the views and needs of government research and the universities. The Fifth Plan considers S&T as a principal dynamic force affecting all important sectors. A small "R&D work group" has been established within each appropriate vertical commission. Some of its members are on the commission; others are called in as consultants (*7*). Each work group will write an R&D section for its vertical commission's report. The group will analyze the goals and technological potentials of its sector and try to outline the size and nature of the technical manpower, fiscal, and equipment resources needed to meet its commission's goals. Finally, it will suggest government policy changes needed to support its commission's R&D objectives. The R&D work group thus provides a powerful vehicle for stimulating greater coordination of scientific research and public policy in each sector.

But the activities of all sectors need coordination to maintain fundamental economic and social balances. This is the function of several "horizontal commissions" (on economics and finance, manpower, regional development, productivity, and scientific research) (*8*). The horizontal commission for Scientific and Technical Research was established in August 1960. This commission consists of the entire Consultative Committee plus certain "members by right" (*9*). Its primary functions are to oversee and coordinate the R&D work groups within the vertical commissions and to draw up a total national plan for scientific and technical research. Coordination between work groups is assured, wherever possible, by having at least one member of the "horizontal commission" on each vertical commission's work group. Unfortunately this means that France's key science policy makers, Consultative Committee members, are heavily overburdened. They generally serve on the Consultative Committee, the horizontal commission, and a vertical committee work group, yet must also carry full-time responsibilities as scientists or executives in major research laboratories.

After the final plan is drawn up, the "horizontal commission" for research will publish its report, "La Recherche Scientifique et Technique," for dissemination by the Planning Commissariat. During the Fourth Plan this document was reportedly written by the General Delegation's Planning Service. It laid down only broad philosophical guidelines rather than concrete technical recommendations. But with improved data and broader participation of the technical community in the Fifth Plan, the next report will perhaps be more explicit and useful.

### Public-Private Research Planning

A brief description will help to demonstrate how this complex organization actually works out a coordinated National Plan and its associated science policy. After thorough statistical analyses and much high-level political discussion, the government establishes broad national goals for the forthcoming 4-year period. These are purposely set a little high to stimulate creative thinking and a positive national effort. The goals finally agreed on for each plan have varied considerably, but in broad measure they have been attained or exceeded. The First Plan (1946, 1952–53) was essentially aimed at reconstruction and at bringing basic industry's productive capacity up to pre-World War II levels. The Second Plan's principal objectives were to further expand capacity in basic industries, to improve productivity in all sectors, and to expand the gross national product by 25 percent between 1952 and 1957. The Third Plan (1958–1961) was primarily to prepare France for entry into the Common Market. Its "imperative tasks" included: increasing domestic production by 27 percent and consumption by 24 percent, restoring the balance of payments, providing capital equipment for future expansion, undertaking "social investment" in housing and education, encouraging vocational education and research, limiting the growth of Paris and its suburbs, and providing increased technical assistance to underdeveloped countries. The primary objectives of the Fourth Plan (1962–1965) were to: increase GNP by 24 percent, change the energy balance of France, modernize public transportation facilities, increase telecommunication facilities, improve tourism and public services, obtain full employment, create a surplus balance of payments, place research and development in a high-priority position contributing to economic and social goals, and improve the living standard of less favored national groups and regions. Each plan also established more detailed and quantitative objectives for each important sector.

After broad objectives are set, there begins a process of "elaboration" in which each vertical commission estimates its potential contributions toward accomplishing the objectives and forecasts the demands its activities will place on all other sectors. This process is best illustrated by showing how a specific commission, for example the Energy Commission, would operate. Let us assume that the government has set certain broad targets which directly affect the energy sector. These might include a total economic growth of 5½ percent per year, a positive balance of payments, and the continued development of a more flexible, lower cost, energy base for France. These targets are presented to the Energy Commission along with a questionnaire concerning the potential contributions and needs of the energy sector during the period to be planned.

The Energy Commission, representing both nationalized units and private

concerns like the major oil companies, then analyzes energy demand for the next 4 years on a national scale. The energy demands of each major market (such as highway transportation, household, industry, railroads, aviation, power stations) are forecast, using both broad economic indicators and specific demand data from other commissions (such as those on transportation or housing). From this the Energy Commission estimates future demand for each primary energy source: solid fuels, petroleum, hydroelectricity, nuclear energy, and gas. As these forecasts are developed, the R&D work group counsels on the expected technical "state of the art," outlines the R&D plans of major government laboratories, recommends fields needing greater (or less) emphasis, estimates the sector's total technical manpower needs, and suggests policies helpful to the development of required technologies. The commission's final forecasts are then converted into growth and productivity objectives and into fiscal and manpower demands for new energy capacity, modernization of facilities, development of proved fuel resources, exploration for new resources, research and development programs, and so forth.

While such analyses are going on, the Planning Commissariat and the horizontal commissions constantly see that common national account data are used by the vertical commissions, that each commission is aware of the market demands and supply restrictions imposed by other commissions, and that all plans are aligned to meet expressed national goals. For example, if the horizontal commission for research saw that the Energy Commission's plan to develop nuclear energy rapidly would draw off too many physicists from other key areas, it would try to persuade the Energy Commission to modify its plans. Similarly the Commissariat would inform the Manufacturing, Iron and Steel, and any other appropriate commissions about the demands the energy sector would create for their products and technologies.

When the physical and financial coherence of its plan is finally established relative to those of other commissions and national goals, the Energy Commission will write a report establishing specific objectives for each of its major components and recommending governmental policies needed for their accomplishment. Such policies for R&D might include the continuation of rapid depreciation allowances for gas and petroleum research, de-emphasis of coal research, and special credits to international companies performing research in France. Its report will then be synthesized with those of other commissions, approved by the government and its highest economic and social councils, and sent to the National Assembly as a "law program."

When accepted by the National Assembly, a plan becomes "the law of the land," that is, a 4-year commitment by the French government to help achieve the objectives it sets forth. During this period, the activities of nationalized units will be controlled to fulfill their share of final objectives. The Commissariat will also report to the government on progress in carrying out the plan and give the Assembly an analysis of how each major legislative proposal will affect accomplishment of the plan. Private companies will merely use data from the plan and their sector's objectives as guidelines. If the objectives are well formulated and government support is consistent, companies will tend to support the plan voluntarily, but little attempt—other than through the use of broad incentives noted above—will be made to force individual companies to comply with the plan in detail. The French emphasize that the plan must be flexible to meet new challenges and that individual initiative and continual adjustments are necessary in its detailed execution. But they expect the plan to provide consistent objectives, data, and policy guidelines which will lend cohesiveness to public and private action during the period of the plan.

By including private research in the Fifth Plan the government hopes to (i) force industry to think ahead about its R&D commitments and their relationship to the total economy; (ii) relate industrial R&D activity to that of other sectors in order to better understand and balance total national commitments; (iii) obtain guidelines for the nature and amount of assistance needed to properly develop each specific sector of industrial science and technology; and (iv) establish better priorities for government science and education programs to meet anticipated industrial needs. While industry has been willing to cooperate by informing the government —through industry-wide syndicates— about its planned R&D expenditures, it will not forecast specific new product or process technologies. Nor will it disclose strategic plans or proprietary technical information. Nevertheless, the government is better informed about industry's technical plans than ever before. And business-government relationships in this area seem to be conducted in an atmosphere of increasing mutual confidence.

### Other Coordination Groups

Although the plan and the science policy groups described above achieve substantial coordination of French research, other organizations play an important role in this regard.

The Centre National de la Recherche Scientifique (CNRS) is undoubtedly the most important single force in French fundamental research, and it may be the most centralized establishment of its sort in the Western world. CNRS supports virtually all scientific research projects in the universities and has its own specialized laboratories in certain fields.

CNRS reports to the Minister of Education in parallel to the universities and the education-policy hierarchy of the "*grands établissements*" (Museum, Collège de France, Écoles Normales Supérieures des Hautes Études). Internally it is organized into committees representing the different disciplines within its total purview (including certain of the social sciences and humanities). These committees are made up principally of professors in the respective fields and scientists and administrators from CNRS laboratories. But in an attempt to better align CNRS research toward national needs, a decree of 9 December 1959 widened the membership of the CNRS directorate and key national committees to include engineers, scientists, and economists from outside the Ministry of Education. The committees of CNRS periodically prepare the "Rapport de Conjoncture," which for each discipline describes the main lines of research anticipated and details its most important facilities and personnel needs for the succeeding several years.

The degree to which the CNRS committees and the "Rapport" influence policy is unclear. Many people claim CNRS dominates all French research. Yet, despite widespread discontent, for years CNRS salaries have been low—comparable to those of civil servants instead of industry or other government scientists—and job security has been minimal. Even after the substantial reforms effected by the Consultative Committee in 1959, there is no pension or security in CNRS until one reaches the fairly

senior title of Attaché de Recherche. Many laboratories feel unduly restricted in obtaining equipment. And acquiring additional personnel, or even transferring people from one laboratory to another when this might benefit both the laboratories and individuals, is extremely difficult. However, most people I contacted thought the science-planning process had helped to bring these shortcomings to light and that some reforms were taking place, though not rapidly enough to meet the future scientific-education needs of France.

One of the most serious failings of CNRS and university science is its isolation from applied research and technology. The universities are extremely proud of their emphasis on research which lacks pragmatic orientation, and long resisted even establishing departments of applied science. Academic practice and Ministry of Education policies have militated against fruitful relationships with science-using groups, particularly private industry. Professors are discouraged from acting as consultants to industry. If a company wants to support research in a university, its funds must normally go to CNRS or the university. The company rarely can make a contract with an individual professor or university research group. Individual researchers and industrial concerns may help each other with tests, assays, and so on, but such relationships are unusual. Publication, not application, has been the goal of university research. The result is a schism between university research and science-using groups in industry and government that has yet to be successfully bridged.

Several recent actions have attempted to facilitate relationships between the universities and other technological groups. A Service of Inventions has been established in CNRS primarily to increase exploitation of university research. Inventors submit their ideas to the Service for screening. Over 10,000 documents are received each year. These result in some 200 invention dossiers and eventually in about 50 patents. The Service can assist the inventor in building prototypes, developing his patent position, and contacting potential licensees. If the patent is successfully licensed, CNRS and the inventor share the royalties (usually 25 percent to CNRS and 75 percent to the inventor). Whether the Service will extend its support into development activities, pilot plant construction, or market development—as has the National Research Development Corporation of England—is an open question. But the Service of Inventions is a significant first step in improving application of university and CNRS research results.

### Development Funds; "Round Tables"

The Development Funds for Scientific and Technical Research are a unique French idea for improving scientific coordination. The Funds provide flexible supplements to approved R&D budgets. Although of limited size (290 million francs, or about $58 million, from 1962–1965) they allow the government to move quickly between formal budget periods to support scientific areas which achieve sudden importance or urgency relative to national interests. They also allow the government to "seed" new areas of research in France, to support needed facilities in important fields, or to bring together several specialized scientific groups or individuals to launch coordinated programs (called "concerted actions") on selected problems.

In administering the Funds, the General Delegation seeks advice from the Consultative Committee and from "round tables" formed to identify the specific areas in which "concerted actions" are needed. The Delegation appoints a round table of about 20 members from a selected list of about 500 people in industry, government, and university laboratories. Each round table draws up a list of approximately 12 of the most significant technical problems within its particular sphere (electronics, water resources, high-polymer chemistry, and so on). This list is submitted to various knowledgeable organizations, including appropriate industrial concerns, to suggest priorities among the problems and to propose specific approaches for research. A round table subcommittee then recommends to the General Delegation which specific projects should be supported and in which government or private laboratories.

Round table discussions have been divided into two basic series. The first program (1961) of "concerted actions" was concerned primarily with basic research and involved discussions of applications of genetics, cancer and leukemia, molecular biology, energy conversion, documentation, marine exploitation, neurophysiology and psychopharmacology, animal and human nutrition, economics and development problems, space research, and demographic, economic, and social analysis. The second program (1963) of "new actions," emphasizing applications more than basic research, has discussed agriculture, building and civil engineering, earth sciences, electronics, computers, automation, high-polymer chemistry, large-accelerator design, and precision mechanical engineering. These are not discrete groupings, nor is the list of "new actions" complete. Further discussions are probably going on at present, and both the topics and format of the round tables are constantly evolving to meet France's changing needs.

The most significant feature of the round tables is that for the first time industrial and university scientists have been brought together to discuss their joint roles in providing needed technology for the country. For the first time, the university professor has been asked to look at the possible technological implications of his science, and industrialists have overcome enough of their suspicions to discuss some of their scientific needs with government scientists and educators. So strong were the biases of both groups that it took over a year just to work out an initial format acceptable to all parties. But the round tables represent real progress. As one member of the General Delegation said, "Five years ago this kind of relationship would have been impossible. But the Common Market has finally forced industrialists, academicians, and government people to work together for a common good."

One other coordinating mechanism deserves special mention. A major criticism of planning discussions in the past was that they were too much oriented toward short-term problems to provide useful guidance for long-term commitments such as education and research. Consequently, for the Fifth Plan the General Delegation has established a series of "description groups" to study the long-term (through 1985) outlook for each specific scientific discipline, its most significant and likely contributions, and its probable training and facilities needs. These projections are only to anticipate major trends, not to stimulate specific current action. But some members of these "description groups" will also serve on the R&D work groups of the vertical commissions and on the round tables described above. They thus should bring a longer-term orientation to other planning groups. And they should be better able to see their sciences in the context of

the long-range resources and needs of France.

All of these organizations are intended to develop a sounder, more efficient scientific and technical base for France. But have they? What contributions have they made to date? Is France better off with or without S&T planning? There is no question in my mind that France has gained a great deal from its efforts to date and should continue to do so in the future. Although the planning structure must continue to evolve to meet new challenges, it has already made many significant contributions. Three broad accomplishments are immediately apparent:

1) For the first time France has begun to develop organized data about its scientific and technical commitments. Only in the last two years has the National Inventory obtained enough substantial R&D information from industry to make informed guesses about industrial research activities. This information is still subject to a great amount of error, and it will take time to work out problems of definition and reporting. But at least French national economic, manpower, and political policies are no longer being made in a void of scientific and technical data, and the groundwork is laid for improved information in the future.

Further, the coordinated exchange of information among various economic sectors gives industries a more adequate base for forecasting sales levels, technical potentials, and resource needs. It provides much data, which would not otherwise be available, on the plans of interrelated sectors such as the fuels, energy, basic metals, and manufacturing industries. Such data are essential in order to realistically estimate trained-manpower requirements, forecast S&T investment needs, and allocate scarce human and capital resources.

2) The French government can obtain competent top-level advice on scientific affairs in an orderly, timely fashion and with thorough staff analysis. The planning process tempers the effects of pressure groups or lobbyists and offers science policy makers an opportunity for a more balanced viewpoint than they might otherwise achieve. Pressure groups must relate their activities to common objectives, and all major sectors have an opportunity to influence national S&T policies. The tendency is to produce a more consistent government policy which allows better coordination of ministry activities and improved allocation of government and nationalized-industry investments in S&T.

3) Organized planning has educated a number of national leaders. It has intimately involved key industrialists, academicians, union leaders, and political figures in initiating and coping with technological change. These people's increased capacity to relate their activities to total national objectives may well be the most important single contribution of the planning process. Major attitude changes were essential in industry, unions, and government to permit the enormous technological changes which have: (i) made oil and gas, rather than coal, chief sources of energy in France; (ii) created independence of political action through the "*force de frappe*"; (iii) relocated major segments of industry from Paris into the provinces; (iv) shifted national production from agriculture and small-scale industrial products toward complex industrial and consumer goods, while maintaining full employment and sustained economic growth; (v) thrown specific industries into increasing direct international competition both within the European Economic Community and in non-European markets; and (vi) brought about enormous cultural and social changes in regions relatively unaffected by technology for centuries past. It is doubtful that this much change could have been so swiftly wrought in tradition-laden France without the degree of cooperation and education the planning process elicited.

In addition to these broad benefits, planning activities have stimulated specific actions of major consequence.

There is an increased emphasis on science and S&T training throughout France. The percentage of the gross national product devoted to S&T activities has increased steadily in the last several years to an approximate 1964 level of 1.7 percent (*10*). This growth has been especially important in increased emphasis on the applied sciences.

For the first time university research has begun to be related to national needs. The round tables, vertical commissions, and long-term study groups have forced constructive contact between the academic, government, and industrial communities. Decrees have been proposed which will permit contracts between individual university researchers and industry. And departments of applied science have been created in several provincial universities to train people who can help bridge the traditional gap between basic research in universities and the use of science in the solution of the nation's economic and social problems.

The Consultative Committee's advice has effected many reforms in CNRS. CNRS committees have a wider representation from outside the academic community. Researchers' salaries have been improved, as have tenure and retirement privileges. And funds have been provided to better equip CNRS laboratories.

The actions of the Consultative Committee and Funds for Development have initiated significant scientific activities in the important areas of space, atomic energy, microbiology, human health, agronomy, and computer components.

France has been able to extend its scientific and technical capacity through better organization of international cooperative programs. These include ORSTROM, (Office de la Recherche Scientifique et Technique d'Outre-Mer), European Economic Community groups, and cooperative ventures such as the Concorde supersonic aircraft project and the nuclear center of the European Organization for Nuclear Research (CERN). Such efforts help France achieve an impact with her S&T resources she could not achieve alone.

National S&T planning is, of course, not solely responsible for these developments. But it has undoubtedly provided more rapid coordinated action.

## Present Weaknesses

Despite its substantial contributions to date, the French S&T planning approach faces many present difficulties and has yet to cope effectively with some important science policy problems. Its most serious present weaknesses are the complexity of the planning organization itself, its committee approach, the potential power of the General Delegation, and the organization's inability to obtain significant action on certain questions. Let us consider each of these briefly.

1) The S&T planning organization is so complex that even people in key positions are often unaware of the total apparatus or of the specific activities of certain groups. For example, members of the Consultative Committee cannot always keep up with all of the active "work committees" in the total organization. There is such a shortage of com-

petent scientific and technical people that a few people are involved in many different activities. While their simultaneous presence on several committees may provide a consistency of outlook, it certainly means a lack of full-time attention to any of the significant problems they are attacking. And in their multiple roles many key scientific and technical people are frequently serving as the nation's judges in evaluating the roles of the very laboratories or specialties for which they must be solicitors. Thus, the people who are responsible for using government R&D money are actually judging the adequacy of their own plans.

2) The committee approach has several important drawbacks. A committee can always be formed to prove anything by proper selection of members. The objectivity of individual committees may thus be questioned. For example, the Consultative Committee has always been heavily loaded in favor of fundamental research. This undoubtedly has affected the whole outlook of research in France, where—despite its dominant problem of obtaining better application of science and technology—fundamental research on esoteric problems is still much more the vogue in government-supported laboratories.

Committee discussion does not always bring out the deepest issues or the most important questions regarding the frontiers of research. Few organizations will disclose their most imaginative thinking, and they certainly will not disclose any proprietary information. Nor does committee discussion encourage the risk-taker. Committee reports tend to be generalized to obtain a consensus and may not at all represent the best individual thinkers in the group. Finally, there tends to be backscratching within the committees with an attitude of "don't hurt anybody." Such problems may not have been too serious to date because science policy actions have been directed primarily at obtaining higher support levels for almost all sectors. It has been unnecessary to "hurt" anyone. But when hard choices—such as the decisions of Britain or Sweden to wipe out or reorganize entire industries in order to make the whole economy more effective—face France, the "voluntary committee" approach may simply break down.

3) The General Delegation may wield more power than is desirable. The all-pervasiveness of the General Delegation's influence undoubtedly helps to coordinate all scientific and technical activities in France. But its extensive liaison activities, its position as the sole staff unit for the three most important science policy groups in France, its appointment of certain technical committees, and its control of the Funds for Development give the General Delegation enormous influence in allocating French scientific resources. Although so much influence always poses the threat of debilitating over-centralization and the misdirection of science, there has been no apparent misuse of the General Delegation's powers to date. And there are significant formal and informal limits to its influence in both the public and private spheres.

4) Another problem is the incapacity of the planning apparatus to obtain meaningful action on certain recommendations. The S&T planning structure is essentially advisory. The President, Minister of Finance, and a few other key political figures actually formulate and enforce significant national policies. If they are convinced of the merits of scientific advice they will follow it. If not, they will decide as they see fit. Thus, decisions about defense, atomic research, and space are often made completely independently of the scientific policy apparatus. Attempts to reform CNRS and to expand and modernize French science education have never received the political force to carry them out. And measures to increase emphasis on applied research have often bogged down in the entrenched educational and research bureaucracy. Unless key officials convert its recommendations into action, the structure can become just an elaborate information exchange with little policy impact.

These flaws have certainly not outweighed the contributions of France's science policy apparatus to date. But they are significant. And they may prove critical failings as France attempts to cope with its complex future science policy questions.

## Future Problems

Certain problems appear certain to dominate French S&T planning activities for the next 5 to 10 years. Today's planning apparatus will either solve them, mutate, or fail because of them. One can only conjecture which will happen. But these are the critical issues for French S&T planning:

1) An improved analytical framework for committing S&T resources is essential. First, better data are needed on technical education capacities, student enrollments and plans, present R&D activities in all sectors, and future requirements for each technical specialty. Second, there must be analyses of the impact of science and technology on economic and social affairs. Third, more objective techniques must be developed for allocating resources among sectors and ranking programs within sectors. Past S&T plans have been formulated intuitively with inadequate knowledge of the human resources involved and even less understanding about the potential impact of allocating these resources in one way as opposed to another. Such techniques may have sufficed when France's principal problem was to stimulate more effort in virtually all areas. But, as total S&T investments grow and early research matures into costly development alternatives, more systematic analysis will be essential to avoid gross misallocations of precious resources.

2) The total education system must reflect the needs of a modern technological society. Rapid and effective technological change depends as much on competent management, capable engineering, or an adaptable work force as upon elegant scientific solutions. Total educational commitments must be increased and balanced to supply needed managers, applied researchers, engineers, technicians, and skilled workers, as well as scientists. Most serious has been the lack of adequate professional applied research and managerial training in France. Such training has been largely left up to the *ad hoc* programs of individual companies and laboratories.

Further, the whole educational system suffers many anachronistic rigidities. It normally separates the liberal arts and the physical sciences curricula at the *lycée* level and continues the separation through the universities. Once started on one educational "track" in childhood, a person finds it almost impossible to change to another. If a young person performs unsatisfactorily on national examinations

at critical stages in his career, he tends to be shunted aside in the formal educational system with little opportunity to later reenter the system for professional training. Thus, many "late bloomers" and people who want to change careers are lost to science, engineering, and other professions: A dynamic, technologically oriented French society requires a much more flexible educational system.

3) New mechanisms are needed to bridge the gap between fundamental research and technological application. Fundamental science has traditionally enjoyed high status, and theorists have been held in higher regard than practitioners. The best minds have gone into fundamental research; and open publication of results, not patentable devices or useful application, has been the prestigious end point of excellent research. Consequently, discoveries made in France often were first exploited in the United States and other "engineering-oriented countries" with little direct benefit to France.

The need for increased emphasis on the application of science has been recognized and some first steps taken. But it will take years to provide more prestige for applied technical work, to attract and train needed technical people, to build stronger industrial research organizations, to encourage improved intellectual contact between university scientists and the science using communities of government and industry, and to break down traditional rigidities of organization and compensation in CNRS and the universities. These problems will be amplified in developing increased attention to unglamorous areas of civil technology where France has particular needs. Highway engineering, building research, consumer appliances, and soft goods industries are perhaps more important in modernization than sophisticated electronics, space, and nuclear programs. Yet attracting first-rate people to these fields will be difficult.

Many French leaders feel strongly that a device like the U.S. government's contract system is their greatest hope for overcoming educational and industrial inertia. They say contracting could exert a far more direct and explicit influence on individual organizations where change is needed than do present incentives. They believe contracts could be used to break down rigidities between government, CNRS, university, or industrial laboratories. They could stimulate research on specific practical problems and could more easily underwrite important developments for certain industrial sectors or individual concerns. Contract provisions could help introduce better accounting and research management practices throughout the country. And contracts could help enforce desirable allocations of resources to major national programs. Although not a panacea, contracts could provide a powerful tool for progress.

4) The French patent system needs a major overhaul. The lack of Patent Office investigation before a patent is issued and the use of general descriptions of inventions instead of claims has limited the protection provided by French patents. This in turn has decreased the incentive to undertake development risks. Many knowledgeable people stated that the weak French patent system has been a major barrier to obtaining a higher utilization of French scientific results and has had the undesirable side effect of secret development and nondisclosure of useful technologies. In addition to strengthening its own patent protection, France must also consider how it will cooperate in the developing patent organization of the European Economic Community.

5) The size of French industrial units will become an increasing constraint to technological progress as France enters further competition, both within the European Economic Community and worldwide. It has few large vertically integrated companies which have the economies of scale and the technical base to clash head-on with the American, German or British "billion dollar" corporations. Smaller French companies often cannot afford significant R&D programs. Automation and efficient modern marketing require enormous sales bases which many French companies simply do not have. Thus, for international competition certain industries may have to consolidate into larger competing units with their own technical resources. This in turn may obviate many parafiscal research institutes, which in the recent past have provided the technical backup for industries with small competing units. Thus a large segment of the French industrial research structure may face great changes.

Finally, France may have to develop new "support" institutions—such as broader money markets, captive distribution channels, mass advertising, and supermarkets—to expand its investment and marketing base to meet the demands of large-scale, high-volume, complex industrial technology. All of these could cause significant changes in the organization of the French economy, and changes of this scale will not come easily. But they are probable outgrowths of a sustained drive to increase France's standard of living and world role through science and technological advance.

6) As its society becomes more affluent, France's national planning will become more difficult. French planning may have been successful to date simply because there was such a strong latent demand for any production which could be achieved. The real problem of the country has been the allocation of investment and the development of manpower for almost all sectors. Increasingly, economic growth will depend on innovation to increase the propensity to consume. As France enters this new period—as it is expected to in the next 5 years—the nature of the planning process will change markedly with the uncertainties of imaginative competitive marketing, creation of new products, and fickle consumer response, added to the ordinary problems of forecasting demand and output in each sector. These uncertainties will be reflected in more complex manpower and educational planning problems in the technical sphere. Manpower allocation will become more difficult as private companies increasingly bid for technical people and the percentage influence of direct government investments in the S&T sphere decreases. This shift to a more decentralized affluent economy will provide the real test of S&T planning in France.

These are immense demands to be placed on a planning structure which has existed so short a time. But they are the problems of France's future. The only question is whether France should formally plan to overcome them or let the invisible forces of private choice lead where they may. Unfortunately, many of these issues are deeply imbedded in the French culture, and powerful forces will naturally resist needed changes. Consequently, I believe that the only way for France to overcome these problems (and hence

to remain in the front rank of modern nations) is to attack them vigorously and with the participation of all who will be involved in the change. And this is precisely what the French S&T planning apparatus is attempting to do. The apparatus must mutate to meet France's new needs. But a logical start has been made.

## Summary

The imaginative French attempts to plan civil science and technology in a basically private-enterprise economy merit worldwide attention. The basic French S&T philosophy and structure are described here for the first time in any very complete form. The planning apparatus has made many important contributions to France's recent scientific and technological development. This article has attempted to document both these contributions and the major weaknesses in the current planning structure. And it has noted the major problems French S&T planning must face in the future. Undoubtedly the planning structure will continue to evolve to meet these challenges. But the real question is whether it can do so fast enough or completely enough to cope with the urgent demands of future international competition, increased industrial consolidation, more flexible educational and research organizations, and a more decentralized affluent society. Perhaps an even more proper question is whether France could hope to meet these demands *without* intelligent planning of its scientific and technical commitments.

### References and Notes

1. A. M. Weinberg, "Criteria for scientific choice," *Minerva*, Winter, 1963.
2. P. Bauchet, *Economic Planning, the French Experience* (Praeger, New York, 1964), p. 77.
3. Derived in part from *La Recherche Scientifique en France* (Délégation Générale à la Recherche Scientifique et Technique, Paris, 1964). Important national laboratories such as the Institut National de la Recherche Agronomique, Institut National d'Hygiene, Centre National d'Études Telecommunications are included in the "laboratories" reporting to the ministries.
4. As of this writing, these include: Minister of Education (universities, CNRS, Natural History Museum, Collège de France, Paris Observatory, most of the "*grandes écoles*"); Minister of Agriculture (Institut National de la Recherche Agronomique); Minister of Industry (Bureau of Geological and Mining Research, Geological Map Service, National Institute of Applied Chemical Research, nationalized coal, gas, and electricity industries and their laboratories, "parafiscal" cooperative industrial research associations); Minister of Public Health (Institut National d'Hygiene); Minister of Posts and Telecommunications (Centre National d'Études de Telecommunications, CNET); Minister of the Armed Forces (Defense Research through the Delegation Ministerielle pour l'Armement); Secretary of State for Scientific Research (Atomic energy, space research).
5. Actually the decree of 29 November 1958 created only the post of General Delegate for Scientific and Technical Research. The General Delegation, of which he is head, was not created until 1959.
6. There are commissions on: Agriculture; Agriculture and Food Industries; Building and Public Works; Chemistry; Commerce; Cultural Investment; Energy; Fuels; Fats; Handicraft Trades; Housing; Iron and Steel; Manufacturing Industries; Mines and Non-Ferrous Metals; Overseas Development; Postal and Telecommunications; Broadcasting and Television; Health and Social Investment; School, University and Sport Investment; Sea Fisheries; Tourism; Transport; Urban Development (*2*), p. 35.
7. The typical work group would have three to ten people intimately involved, with a large number of people called upon temporarily for specific assistance.
8. J. Hackett and A. M. Hackett, *Economic Planning in France* (Allen and Unwin, London, 1963), p. 46.
9. Currently, these are the "members by right": Director of the Budget, Director of the Treasury, Chief of Service—Economic Studies and Finances (Ministry of Finance), Delegate General for Scientific and Technical Research, President of the Action Committee for National Defense, Chief of the Technical Bureau of the State—Major General of the Armies, Inspector of Armament Programs and Production, the Delegate Administrator General of the Government and the High Commissioner of Atomic Energy, Director of University Education to the Education Ministry, Director of the CNRS, Director of the National Institute for Agricultural Research, Director of the National Institute of Health, the Inspector General responsible for Technical Research for the Ministry of Industry. The President of the Center for Space Studies and the Director of Research and Testing of the Ministry of the Armed Services are more recent members.
10. Source: letter, 18 May 1965, Office of the Scientific Attaché, Embassy of France, Washington, D.C.
11. This article results from a one-year study of national science planning in Europe. I interviewed 177 high-level people in universities, businesses, government, and independent institutes. I thank the Ford Foundation and Alfred P. Sloan Foundation for their support and the Conseil National du Patronat Français for arranging interviews throughout France.

**NEWS AND COMMENT**

# After the Moon Landing: Senate Hearings Open Way for Debate

"We are involved in a great many things that we decided long ago with very little discussion," said Senator Clinton P. Anderson (D–New Mexico) in reference to Project Apollo, the program for a manned round trip to the moon in this decade. The Senator, who chairs the Aeronautical and Space Sciences Committee, made it clear that he feels Apollo is "a fine goal," and he added, "I am glad that we have gone ahead with it." But future goals for the space program, he declared, should be preceded by ample public discussion. The Senator made his remarks in the course of three days of hearings held in August and published with supplementary material earlier this month, under the title "National Space Goals for the Post-Apollo Period."* The 383-page volume comprises the best available compendium of what the officialdom of space is thinking of post-Apollo, and, especially for those who share the Senator's views of the genesis of the moon program, it commands serious attention.

The object of the hearings was not to determine what any concerned citizen feels about post-Apollo, but rather, as a staff member of the committee explained to *Science*, "to get the views of the people who have a major input on the program. It was not intended as a public sounding board." This may strike some space skeptics as a closed-circuit discussion. But the relevant fact is that post-Apollo planning is now in the most preliminary stages of discussion, and the official views elicited by Anderson's committee provide informa-

* $1, U.S. Government Printing Office, Washington D.C. 20402. Also available, for 40 cents, is a related volume, part 3 of "Hearings Before the Aeronautical and Space Sciences Committee," containing various post-Apollo planning documents, including the Future Programs Task Group report.