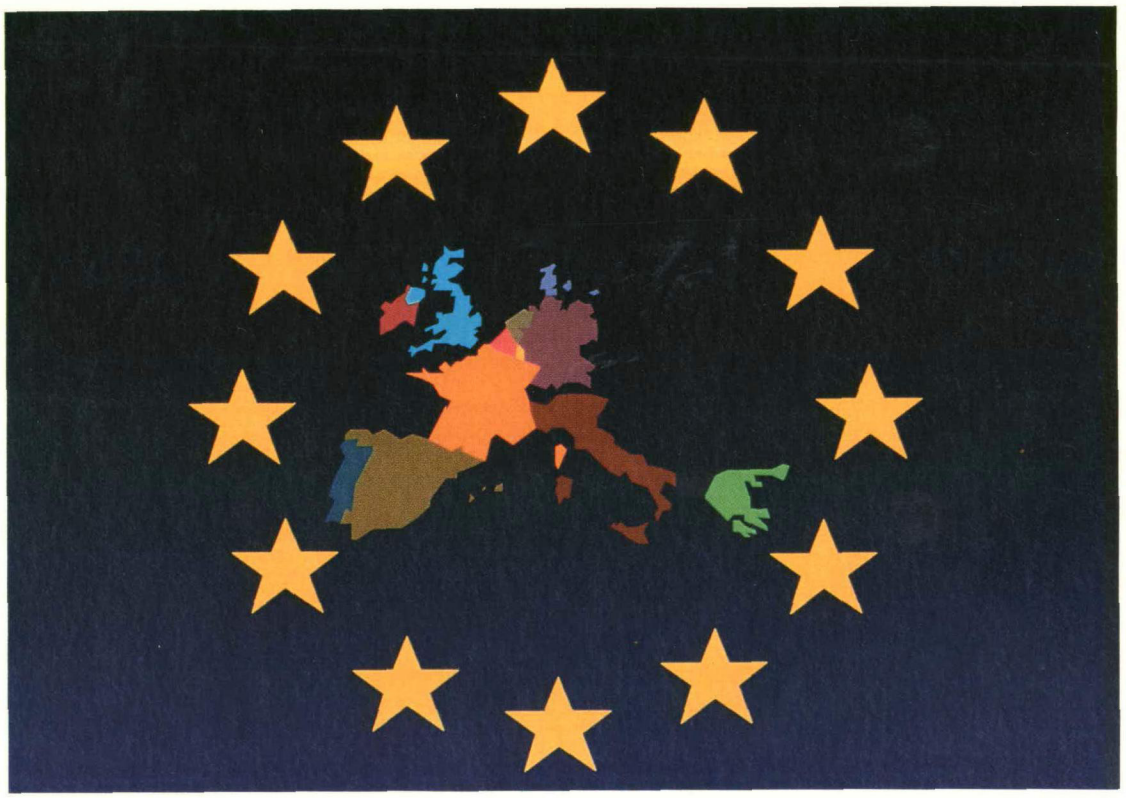
SCIENCE AND TECHNOLOGY INTEGRATION IN EUROPE and INFLUENCES ON U.S.-EUROPEAN COOPERATION



A Report of the
NATIONAL SCIENCE BOARD
Committee on Europe in 1992

November 1990

NATIONAL SCIENCE BOARD

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NATIONAL SCIENCE BOARD

WASHINGTON, D.C. 20550

November 7, 1990

MEMORANDUM TO: Mary L. Good, Chairman
National Science Board

FROM: James B. Holderman, Chairman
NSB Committee on Europe in 1992

SUBJECT: Final Committee Report

The Committee on Europe in 1992 have completed their work on a final report, reflecting the charge to the Committee "to consider the issues associated with Europe in 1992: Implications for U.S. Science and Technology," given in your memorandum of May 10, 1989. I ask that you present the report to the Board at its November meeting, with a request that it be adopted by the Board. I and the rest of the Committee will be pleased to discuss any questions or concerns of Board members. The report has been mailed to all NSB members for their review prior to the November Board meeting.

The report is composed of two sections: a descriptive assessement of the evolving nature of multilateral, primarily EC Commission-funded, science and technology cooperation within the European Community; and a review of challenges for US policymakers, along with current or potential US-EC issues and relevant recommendations for US actions. It is accompanied by a considerably more detailed study prepared by the National Science Foundation staff member who serves the Committee as its Executive Secretary.

Since the report is prefaced by a short Executive Summary, I will not review here its findings. I will note, however, that the Committee are convinced that a serious appreciation of changes taking place in the European S&T environment is of paramount importance to the future of US science and technology. Correspondingly, we strongly support not only the specific recommendations included in the report, but also the view that the National Science Board should continue to address its chartered role of advising on a wide range of policy matters in international S&T relations that directly affect the health of American scientific and engineering research. Particularly, the NSB and the NSF have a critical and essential role to play in encouraging 1) increased efforts devoted to the strategic assessment of European Community (and other foreign) S&T activities and their influence on U.S. S&T; and 2) greater coherence in government, academic and private sector policymaking relating to international S&T cooperation and competition.

On behalf of the Committee, I extend our thanks for your continuing support throughout the past year for our work. We hope the attached documents meet the challenge presented to us in the Committee's charge and that you will find them useful as a guide to issues and opportunities relating to European S&T that the Board will consider in the future.

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ACKNOWLEDGEMENTS

The Committee are grateful to a number of people for their contributions of time, expertise and commitment in assisting the Committee to understand the nature of science and technology in Western Europe and in providing information and counsel in the drafting of the report.

We wish especially to recognize Ambassador William Brock, former U.S. Trade Representative, and Mr. Gilbert Fayl, Science Counselor for the Embassy of the European Communities in Washington, for their extensive and invaluable briefings before the Committee.

The report, including especially the appended background study, rests in large part on the generosity of a large number of persons who provided information and assessments on European science and technology, as well as its place in the larger scheme of economic and political change in Europe. Many others gave freely of their expertise to interpret and evaluate that change, adding perspective to our views of its influence on the U.S. research base.

Among those in Washington whose contributions have been most helpful and sustained have been Regine Roy of the EC Embassy; John Boright, William McPherson and Andrew Reynolds of the U.S. Department of State; Robin Gaster of the U.S. Office of Technology Assessment; Thomas Ratchford and Sara Bowden of the Office of Science and Technology Policy; Mark Lieberman and Susan Lipsky of the U.S. Department of Commerce; Philip Schambra, Gray Handley and Robert Eiss of the National Institutes of Health; and Desmond Dinan of George Mason University.

In Europe, the list is far too lengthy to offer adequate recognition in this space. We wish to note, however, that senior science and technology officials throughout the EC, in the member state governments as well as in the EC Commission, have been extremely open, informative and helpful throughout the period of the study. We would be remiss not to mention the steady support and assistance of Patrick Johnson and Thomas Owens of the National Science Foundation office in Paris, or those of Patricia Haigh and Anthony Rock at the U.S. Mission to the EC in Brussels.

Many persons on the staff of the National Science Foundation provided assistance and expertise to this undertaking, through their participation in Committee meetings and their comments on the earlier drafts of the report. We especially wish to recognize several, however, whose commitment to the Committee's work was invaluable and who provided the necessary administrative and logistical underpinning to see it to completion: Karl Willenbrock, Richard Ries, Robert Hardy, and William Blanpied. Our special thanks go to Richard Bradshaw, Executive Secretary to the Committee.

This report was adopted by the National Science Board at its regular meeting on November 16, 1990.

EXECUTIVE SUMMARY

The recent evolution of science and technology (S&T) policies and programs in Western Europe gives strong indications of a developing umbrella structure for S&T strategic planning, research coordination and resource development. The EC Commission is not the only locus of multilateral research and research-related activities in Western Europe, but it is rapidly becoming the largest source of funding and administrative and planning resources for such cooperation. The principal characteristics of this evolving organizational paradigm are as follows:

- multilateral S&T cooperation within the EC appears to be leading to integration of overall policymaking, strategic R&D planning and coordination of resource creation and allocation, strongly influenced and led by the EC Commission;
- all EC members support this cooperative paradigm, to varying degrees, while the EC Commission assumes a growing but contentious role in stimulating, guiding and making it operational, incorporating it in the larger movement toward economic and political integration;
- the EC Commission is moving quickly to develop policies and activities to support international cooperation in S&T; on several important topics, such as environmental protection and global warming, the EC represents the member states collectively in the international arena;
- the EC member nations' primary responsibility for research support, facilities and human resources remains paramount; the EC superstructure is to be *integrative*, and *supplementary* of member state S&T undertakings;
- the evolving situation in Western Europe implies significant challenges facing US decision-makers, chiefly: 1) obtaining an accurate, comprehensive assessment of European S&T integration; 2) resolving differing internal US government views about exercising US influence on that process; and 3) allocating, or reallocating, resources among bilateral and multilateral cooperative activities;

Six areas of concern in US-European S&T relations are highlighted by this report, with appropriate policy and operational recommendations. Those **most pertinent to NSF**, suggesting possible action on the agency's part, are as follows:

- *US Government S&T Relations with Europe:* NSF should institutionalize and expand ongoing contacts and cooperation with the EC, using the newly-established US-EC Joint Consultative Group on S&T as a mechanism to stimulate cooperation and concertation of international S&T activities.
- *US-EC Human Resources: Supply, Education and Mobility:* Increased U.S. efforts to support pre- and post-doctoral exchanges should include exploring a joint US-EC program of one-year research sabbaticals.
- *US Access to European Research Programs and Results:* A joint US-EC database and communications network for S&T information and research programs and results should be developed and funded.
- *Collection, Assessment and Dissemination of European S&T Information:* NSF information collection & assessment and policy support capabilities regarding European S&T should be increased and utilized more widely.
- *Civilian Research and Technology Assistance to Central and Eastern Europe*: A US-EC effort should aim to familiarize East European researchers with Western R&D management practices, to better utilize Western technology transfer and to promote innovation and market-oriented research & technology development.

Introduction

"Few, if any, developments since the end of the Second World War have influenced the course of science and technology (S&T) in Europe so extensively, or potentially so radically, as the evolution of the European Communities (EC), specifically the constitutional revision in 1987 that produced the Single European Act and brought S&T officially under the umbrella of EC responsibilities for the first time. Scientific and technological integration is occurring within the EC apart from, but parallel to, the 1992 Plan for a fully integrated economic base - the "Single Market." The issues and forces driving economic integration, and its political and social components, apply equally to the realm of S&T."

So opens the staff study which is appended to and forms the substantive underpinning of this report. As those lines were first drafted in the spring of 1990, a large number of those in the U.S. research policy community familiar with European science and technology were still skeptical of the influence of EC economic policies on the progress of S&T. However, even the most dubious should be reconsidering that view in light of recent developments in Europe. With the lightning pace of cohension among European Community governments over the past year on such issues as monetary union, political federation and consideration of a common security policy, a momentum for integration has developed with enough force to override the last holdouts for national sovereignty in these areas—indeed, strong enough to assist in toppling the most prominent advocate of national sovereignty, British Prime Minister Margaret Thatcher.

This report highlights the major aspects of that integrative process and its contributing factors, particularly the role and functions of the EC Commission in S&T and the interplay of S&T policy between the Commission and its chief member nations. The report also takes note of the growing dimension of international relations in Community research and technology activities, pointing the way to a potential, though gradual, evolution of the Commission and Council of Ministers jointly into the dominant coordinating and strategic policy locus within the EC.

The current situation presents several challenges to U.S. policymaking, among them: accuracy in U.S. perceptions of S&T integration in Europe; the most appropriate use of U.S. influence on that process; and the allocation of U.S. public-sector resources for cooperation with Europe. Pointing up the difficulty of responding to these challenges, a review of salient features relating to EC integration and US-EC relations argues for a gradual redistribution and expansion of U.S. efforts, to reflect recognition of the increasing importance of cooperation at the mulitlateral level in, and with, Europe. At the same time, these features taken collectively argue for maintaining a preponderant **programmatic** emphasis on bilateral relations with the member states. Finally the report presents a summary of issues pertaining to that cooperation and provides recommendations for policy and operational responses by the U.S. government generally, and National Science Foundation in particular.

The Role of the EC Commission in S&T Integration

The Commission of the European Communities (the "Commission") has taken the lead role in devising an integrative S&T paradigm for the EC with its FRAMEWORK Programme of multinational applied research and development, which began in 1985. Hitherto independent national S&T policies, research programs and educational planning are increasingly coordinated with and through the EC Commission in Brussels. EC member states have already begun to take the FRAMEWORK policies and programs into account in their national strategic planning and funding decisions, and in the process are beginning to relinquish substantial degrees of autonomy over major areas of R&D activity. Although FRAMEWORK was conceived and implemented separately from the 1992 Single Market Plan, economic integration and its accompanying monetary and fiscal harmonization have contributed greatly to the impetus for change in the organization, method of funding, and policy goals of science and technology in Europe.

The European Research Coordination Agency (EUREKA), although industry-led and managed and not a European Community initiative, is intimately linked on the "downstream" technology applications side to a wide variety of EC R&D programs. As one of the 21 national

members of the consortium, the EC has endorsed EUREKA and participates in those of its projects having a pre-competitive character, where there is a mutuality of interests.

National government planning for S&T is being undertaken increasingly in conjunction with complementary EC research programs, including joint EC-member state consultations on shared responsibilities for emerging technologies and fields of research. Commission leadership in some fields (environmental affairs, nuclear energy research, science and engineering standards-setting, global warming, computers and microelectronics, and large-scale international projects) has already been conceded in large part, at least tacitly, by the EC member countries. The needs of advanced, internationally-competitive R&D activity for access to capital and manpower, for harmonized regulatory regimes, for open and consistent procurement policies, and for barrier-free trade in both products and material resources, all have tied science and technology intimately to the success of the Single Market. As this symbiosis has received wider recognition, S&T has become accepted increasingly in Europe as central to the tightening weave of a federally unified Community.

Significant differences continue to exist among the member states over the preferred, or even permissible, extent of EC responsibility for basic research. Several countries, particularly the smaller and the less advanced ones, appear to welcome the EC role as a stimulus and increment to their own inadequate research base. The principal S&T-performing members have been, until quite recently, ambivalent about or unambiguously opposed to sharing control with the Commission at this level of science. There are definite signals, however, that growing demands on national resources for applied technology investments are beginning to undermine this last bulwark. Commission groundwork for a major role in evaluating basic research needs and stimulating and coordinating national programs is well-advanced, and an extension of its policy and funding involvement is virtually assured.

A Collective EC Voice in International S&T Policies

As authority and power in economic matters has accrued to the EC Commission, and as its influence on national S&T activities consequently has grown, the EC role in regional and global S&T matters outside the Community is expanding significantly. To note the more important aspects of this role, the Commission represents EC countries in GATT negotiations, including topics that have S&T implications; it coordinates the channeling of aid to Eastern Europe, including technological assistance, on behalf of the twenty-four wealthiest industrialized nations (the "G-24", who also comprise the OECD); and it represents the Community nations in international deliberations on environmental pollution and global change issues.

Non-EC countries in Europe are by now sensitized to this aggregation of European S&T decision-making, and the nations of the European Free Trade Association (EFTA) and those of Central and Eastern Europe alike acknowledge their future economic stake in having equal access to EC advanced research, development and human S&T resources in the Community. There are signs that traditionally independent S&T bodies in Europe (such as the European Science Foundation, the European Molecular Biology Organization, the Centre European pour la Recherche Nucleaire [CERN], and the European Space Agency) are moving to accommodate varying degrees of shared authority and responsibilities with the EC, following signals that their national funding sources are acquiescing in a broader, deeper role for the EC.

For industrialized countries outside Europe, this movement provides enormous incentive for a reassessment of the traditionally overwhelming emphasis on bilateral S&T relations. Policies for S&T cooperation that continue to stress the predominance of nation-nation arrangements, without corresponding recognition of the developing overlay of strategic planning and coordinating authority in Brussels, might appear overly cautious. Yet the pace of change and the final parameters of S&T responsibilities in Europe are far from established. Correspondingly, the responses of non-EC countries in realigning S&T relations and cooperative activities *must be measured and in keeping with pragmatic realities* in Europe. However, long-range analysis points to a collective strengthening of European S&T capabilities, increasingly targeted and led by EC Commission policies and research programs, in close coordination with EC national governments and relying on their resources, manpower and facilities.

Challenges for U.S. Policymaking

A large majority of the EC's member governments appear to be increasingly, albeit reluctantly, willing to relinquish traditional notions of sovereignty over S&T matters, as they have done previously in economic affairs. The U.S. is thus presented with a pressing need to develop a coordinated response to a Community-level S&T structure for policy and research programs. Yet U.S. government agencies, including the National Science Foundation, have little substantial knowledge of or prior experience with EC S&T programs, having focused their efforts on bilateral cooperation with individual countries or research field-specific organizations like ESA or CERN. Decision-making is further handicapped by uncertainties, equally prevalent in Europe, over the extent to which future progress in S&T cooperation will be coordinated and centrally-planned from Brussels, or *ad hoc* and directed loosely by national governments.

Several challenges to U.S. policymaking stem from this situation. The first is one of accuracy in U.S. perceptions of the nature, intent and scope of S&T integration in Europe. Current analytical resources and mechanisms are inadequate to provide extensive and reliable information or assessments on individual countries, research fields or overall European capabilities and resources in S&T. Thus it is difficult to make comparisons of these areas either with corresponding U.S. research capabilities or with the policy objectives and claimed accomplishments of European multilateral programs, particularly within FRAMEWORK or EUREKA.

The second challenge involves the resolution within the Federal government of different views on how best to utilize U.S. influence on European S&T evolution. The question remains open in most quarters of how quickly and energetically to proceed in developing a relationship with the EC which, *de facto*, lends support to European multilateral S&T. The question is posed against a concensus on emphasizing the continued predominance of bilateral cooperation with the member states. Looming over this is the more elusive issue of whether openness and cooperation in international research can be maintained and strengthened independently of the often-conflicting interests of trade and commercial competitiveness.

Another challenge is that of resource allocation policy. Given a consensus that recognizes a growing role in European and international S&T for the Community and other European multilateral organizations, the U.S. will be confronted with decisions on measures to support effective collaboration in a multilateral research environment. Participation to any significant degree will further stretch or bring about redirection of U.S. resources devoted to bilateral international cooperation, which by some estimates are already inadequate.

These issues are complicated by uncertainty and some skepticism over whether centrally-guided and administered, multilateral S&T will actually become a reality in Europe. The evidence is far from conclusive that the kind of synergy evolving in Europe in the microelectronics field will characterize other research fields as well. Yet evidence is abundant of an evolution toward some sort of strategic framework for the multilateral utilization of S&T resources. For U.S. policymakers, there is a growing appreciation that the U.S. is already a principal factor in this process, the final form of which is not much clearer in the capitals of Europe than in Washington.

Salient Factors in U.S.-European S&T Relations

As U.S. policymakers begin to define U.S. interests in pursuing a formal relationship with the European Community, there are a number of salient factors relating to EC S&T integration and US-EC relations which should be kept in mind. Some point to apparent divergences in U.S. and Community S&T objectives and research-related activities, while others seem to indicate continuing, even increasing, opportunities for convergence and cooperation. Taken together, they argue for U.S. recognition of the growing importance of Community-level funding for research and infrastructure support, while highlighting the need to maintain for the foreseeable future a strong pattern of bilateral cooperation with the individual member states.

- The European Community, under the provisions of the Single European Act, has a principal responsibility for stimulating multilateral S&T cooperation among the member states, with the aim

of strengthening the scientific and technological basis of European industry;

- Wide variations still exist among EC member countries with regard to total R&D investments, quality and distribution of resources, shares of public and private sector funding, and government S&T policies;
- S&T resource levels, information flows and professional mobility all remain below normative patterns in the U.S., despite significant improvements in all these areas in the last half decade, indicating an S&T base not yet as strong, deep or integrated as that of the U.S.;
- Basic research budgets in the major EC countries are relatively stable or rising only slightly; any significant increases in public funding appear targeted to development of technology with commercial potential.
- The U.S. remains (almost universally in the perceptions of European researchers) a very desirable location for study and research, and European S&T administrators believe that U.S. visits by European researchers will remain high in number over the next decade; these administrators, however, are moving quickly to establish programs to make intra-European exchanges more attractive, promising alternatives;
- The declining demographic pool of European science and engineering students, combined with increasing competition for S&T personnel and emphasis on intra-European mobility, could lead to some decline in the numbers of students and possibly of researchers visiting the U.S.;
- The major emphasis in international scientific exchange for the larger countries of Europe still rests on bilateral programs, and relations with the U.S. continue to be a top priority.
- Continued EC stalemate over S&T funding levels and Commission autonomy in R&D program management could slow the integrative process, making reliable scenarios for U.S.-EC relations difficult to project.
- Although several principal S&T-performing member states are ambivalent about U.S.-EC relations in S&T, the integrative momentum favors a growing and substantial international, as well as a multilateral, role for the EC Commission. This situation imparts a problem of timing, balance and comprehensiveness in the development of an official U.S. relationship with the EC.
- The rapidly growing EC focus on Eastern Europe has resulted in substantial policy attention and bureaucratic resources for external cooperation being turned to that region, creating opportunities for joint U.S.-EC S&T cooperative assistance projects.

Background to the Report

The NSB Committee on Europe in 1992 has based its work, and its findings, over the past year on extensive investigation and analysis by its Executive Secretary and staff of the NSF Division of International Programs. Additional contributions have been made to the Committee by invited experts recognized for their familiarity with science and technology in the European Community. The Committee effort has proceeded concurrently with efforts by a subcommittee of the U.S. Federal Coordination Council on Science, Engineering and Technology (FCCSET), including representatives from NSF, to develop a baseline of information and recommendations for Federal responses to the evolving S&T situation in Europe. The Committee appreciates that the staff work done for it has also been made available to the interagency group, providing beneficial cross-pollination for an understanding of the situation, the issues it raises and the most appropriate U.S. responses.

The appended study, reflecting extensive interaction between the Committee and its author, reviews in greater detail the following areas of relevance for future U.S.-EC relations in science and technology:

- European Community-funded S&T programs, policies, and capabilities
- policies, programmatic emphases and capabilities of key member states

- the EC-member state interface: the economic, political and S&T matrix
- the expanding reach of the EC in international S&T
- challenges of European integration for U.S.-European cooperation
- concerns, issues, and assessments regarding US-EC cooperative relations

The Committee report, supported by the assessments of the NSF staff study, offers recommendations for policy and operational actions by the U.S. government, and particularly by the National Science Foundation. Those recommendations are fully consistent with the General Framework of Principles for International Cooperation in Science and Technology adopted by the Organization for Economic Cooperation and Development (OECD) in 1988. The Committee offers them as encouragement, in both policy development and broad operational matters, for an expanded and revitalized effort by the U.S. government directed to cooperation with Europe.

In particular, the Committee hopes with this report to stimulate recognition of the fundamental changes taking place in European S&T organization, in response to the 1992 Plan, the Single European Act and other integrative factors. It intends to catalyze a broad reassessment of traditional assumptions and patterns of cooperation concerning U.S.-European S&T relations. Finally, it hopes to draw attention to the opportunities for enhanced cooperation presented by the emergence of European multilateral, integrated research initiatives such as the EC's FRAMEWORK programs and its planning and policy coordination capabilities.

Recommendations

U.S. Government S&T Relations with Europe

Issues: How should the U.S. government respond to EC proposals for cooperative activities in specified research fields? What level of official cooperation would best serve the interests of the U.S. research community? Should the NSF pursue an agency-to-agency level agreement with the EC directorates-general for research and technology development? How can NSF utilize the newly-established US-EC Joint Consultative Group on S&T in stimulating more cooperative activities among U.S. and European researchers?

Policy Recommendations:

1) The U.S. government should undertake discussions with the EC, through the US-EC Joint Consultative Group on S&T (JCG), toward some form of agreement on the types and conditions of bilateral cooperation involving EC Commission programs. The composition of the U.S. side of the JCG should reflect a wide range of policy and technical interests.

2) The terms of reference of the JCG, whether formalized or not, should limit its role to that of a forum for consultations, discussion and suggestions for actions bearing upon issues of research, S&T education and mobility, and the infrastructure of both. The JCG should not have authority or responsibility for either funding or operational management of specific cooperative activities. Negotiation and implementation of cooperative undertakings in specific research fields should be devolved to other, appropriate bodies.

3) The NSF should expand and institutionalize contacts with the EC Commission already begun informally. It should utilize the JCG as a primary forum for discussing possibilities, challenges and obstacles associated with stimulating a wider range of multilateral US-EC cooperation and concertation of activities in international S&T.

4) The US government, and NSF in particular, should continue to maintain strong bilateral cooperative activities with the EC member states through policies that are not inconsistent with the development of an overlying US-EC multilateral framework of cooperation. Likewise, an enlarged range of cooperation at the European Community level should not prejudice continuation of successful national bilateral activities.

U.S.-EC Human Resources: Supply, Education and Mobility

Issues: Does adequate support exist, on the part of the U.S. government, academia and industry, for U.S. students and S&T professionals for long-term visits to Western Europe? Should the U.S. government provide greater flexibility and support for foreigners to visit the U.S. for education and professional work in S&T fields? Is continued trans-Atlantic mobility of researchers and engineers linked to a collaborative approach to solving the common problem of an insufficient supply of human resources?

Policy Recommendations:

1) Federal and university laboratories and U.S. private sector R&D-performing firms should be encouraged to seek participation in European basic and pre-competitive research programs at the Community and national levels, in order to improve U.S. access to expanding European investment in S&T and human resources. The U.S. government should attempt to expand the opportunities for such participation and should publicize widely those opportunities that exist.

2) Immigration and naturalization laws and regulations that hinder long-term residence in the U.S. of U.S.-trained foreign nationals with advanced degrees in scientific and engineering disciplines should be modified. Liberalized measures should apply also to foreign career professionals and post-doctoral researchers seeking employment in the United States.

Operational Recommendations:

3) Increased funding should be made available by the U.S. government, through such means as direct competitive grants or interest-free loans, to support exchanges of U.S. and European students for pre-doctoral and post-doctoral study and training. As a beginning measure, the U.S. government, through NSF, and the EC should explore the possibility of a joint program to provide support for one-year research sabbaticals.

U.S. Access to European Research Programs and Results

Issues: In what ways should, and can, the U.S. government intervene on behalf of the U.S. research community to secure equivalent U.S. access to publicly-funded research in Europe? Given the relationship of intellectual property rights (IPR) to access, what is the nature of NSF interests in IPR discussions with the Europeans? Should IPR negotiations be conducted primarily through the EC or directly with each member state government? How can the U.S. and the EC create the widest possible access to information on research projects and results consistent with the objective of openness in public research funding?

Policy Recommendations:

1) If the U.S. government decides to negotiate a cooperative S&T agreement with the EC, the assurance of equivalent and mutual rights of access to research and results of research projects that receive public funding should be included in the agreement; the level of specificity in individual research fields should be left to agency-level MOUs and agreements.

2) A two-track formula to secure agreement on intellectual property rights (IPR) protections with the EC member states individually and with the EC collectively, through the Commission, should be initiated and pursued vigorously by the U.S.

Operational Recommendations:

3) The U.S. should jointly develop with the EC a shared database and communications network for access to information concerning ongoing publicly-funded, civil research programs and projects and their results; access to the network and database should be unrestricted for research communities in these countries.

Collection, Assessment and Dissemination of European S&T Information

Issues: What should be done by the U.S. government to increase the quantity and quality of information and assessment (I&A) on European science and technology? Are NSF and other U.S. government efforts sufficient to provide timely and adequate information about European S&T to policy makers and public users?

Operational Recommendations:

1) The U.S. government should strongly consider expanding its human and technical resources devoted to, and raising the priority assigned to, the collection, reporting, assessment and dissemination of information on European science and technology structures, activities and capabilities, particularly in the context of evolving European integration.

2) NSF should give particular attention to increasing its capability to provide information and assessments of S&T in Europe, with greater attention given to multilateral cooperation in that region. NSF should be encouraged to utilize effectively its existing I&A and policy-support capabilities to expand the scope of cooperation with Europe.

Standards-Setting and Regulatory Processes

Issues: How can the U.S. government most effectively work to ensure that EC standards and regulations pertaining to research are based upon sound scientific criteria and that non-scientific economic or political factors are not included as criteria? What approach should be undertaken to obtain greater openness, or transparency, in the European standards-setting and regulatory processes, especially as they apply to research activities?

Policy Recommendations:

1) The U.S. should strengthen efforts by the Department of Commerce and the U.S. Trade Representative to ensure equivalent transparency and opportunities for mutual, reciprocal participation in U.S. and EC standards-setting and regulatory processes; it should encourage the academic and industry research communities to stimulate participation by experts in U.S. delegations to European standards-making bodies.

2) The U.S. government should continue to provide strong support to EC institutions in their efforts to base Community-wide research and S&T-related standards and regulations on scientific and engineering criteria relating to performance and safety.

Civilian Research and Technology Assistance to Central and Eastern Europe

Issues: Should U.S. policy affecting non-militarily critical technology or know-how promote the transfer of needed scientific and technical knowledge, training, and products to Central and Eastern Europe?

Policy Recommendations:

1) The U.S. government, on behalf of the university, Federal and corporate research communities, should examine potential benefits of a technology assistance policy designed to encourage the acquisition of U.S. advanced research and technology development capabilities by Central and Eastern European countries.

Operational Recommendations:

2) The U.S. government should pursue a faster pace of change, at operational levels of cooperative research programs with Central and Eastern European countries, to remove anachronistic barriers to the exchange and mobility of researchers between the U.S. and those countries.

3) The U.S. should work with the EC to develop a joint program of scientific and technical assistance to Central and Eastern European countries in the field of R&D management. Such a program should stress instruction in modern management tools and techniques employed to effectively implement R&D assistance, as well as to utilize such aid to promote innovation and technological development.

NATIONAL SCIENCE FOUNDATION
International Programs Division

EVOLVING STRUCTURES AND POLICIES OF SCIENCE AND TECHNOLOGY IN WESTERN EUROPE

AND

IMPLICATIONS FOR UNITED STATES-EUROPEAN COMMUNITY S&T RELATIONS

Richard E. Bradshaw

Senior Analyst
Western European Science and Technology
National Science Foundation

and

Executive Secretary
National Science Board Committee on Europe in 1992

October 1990

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EXECUTIVE SUMMARY

Few, if any, developments since the end of the Second World War will prove to have influenced the course of science and technology (S&T) in Europe so extensively or radically as the evolution of the European Communities (EC), specifically the constitutional revision in 1987 that produced the Single European Act and brought S&T officially under the umbrella of EC responsibilities for the first time. Scientific and technological integration is occurring within the EC apart from, but parallel to, the 1992 Plan for a fully integrated economic base—the "Single Market." The issues and forces driving economic integration, and its political and social components, apply equally to the realm of S&T.

The Commission of the European Communities (the "Commission") has taken the lead role in this area with its FRAMEWORK Programme of multinational applied R&D, which began in 1985. Hitherto independent national S&T policies, R&D programs and educational planning are increasingly coordinated with and through the EC Commission in Brussels. EC member states have already begun to take the FRAMEWORK policies and programs into account in their national strategic planning and funding decisions, and in the process are beginning to relinquish substantial degrees of autonomy over major areas of R&D activity. Although FRAMEWORK was conceived and implemented separately from the 1992 Plan, economic integration and its accompanying monetary and fiscal harmonization have contributed greatly to the impetus for change in the organization, method of funding, and goals of science and technology in Europe.

State planning for S&T is being undertaken in conjunction with complementary EC research programs, including joint EC-member state consultations on shared responsibilities for emerging technologies and fields of research. Commission leadership in some fields (human resource development, environmental affairs, energy research, standards setting, global warming, computers and microelectronics, and large-scale scientific projects) has already been conceded in large part by the EC member countries. The needs of advanced, internationally-competitive R&D activity for access to capital and manpower, for harmonized regulatory regimes, for open and consistent procurement policies, for barrier-free trade in both products and material resources, have tied science and technology intimately to the success of the Single Market. As this symbiosis has received wider recognition, S&T has become accepted increasingly in Europe as central to the tightening weave of a federally unified Community.

Significant differences continue to exist among the member states over the preferred, or even tolerable, extent of EC responsibility for basic research. Several countries, particularly the smaller and less advanced ones, appear to welcome the EC role as a stimulus and increment to their own research base. The principal S&T-performing members have been, until quite recently, ambivalent about or unambiguously opposed to sharing control with the Commission at this level of science. There are definite signals, however, that growing demands on national resources for applied technology investments are beginning to undermine this last bulwark. Commission groundwork for a major role in evaluating basic research needs and stimulating and coordinating national programs is well-advanced, and an extension of its policy and funding involvement is virtually assured.

As authority in economic matters has accrued incrementally to the EC Commission, and as its influence on national S&T activities consequently has grown, the EC role in regional and global S&T matters outside the Community is expanding significantly. To note the more important aspects of this role, the Commission represents EC countries in GATT negotiations, including topics that have S&T implications; it coordinates for the OECD G-24 nations the channeling of aid to Eastern Europe, including scientific and technological assistance; and it represents the Community nations in international deliberations on environmental issues.

Non-EC countries in Europe are by now sensitized to this aggregation of European S&T decision-making, and the EFTA nations and those of Eastern Europe alike acknowledge their future economic stake in having equal access to EC advanced research, development and human S&T resources in the Community. There are signs that traditionally independent S&T bodies in Europe (ESF, EMBO, CERN, ESA) are moving to accommodate shared authority and responsibilities with the EC, following signals that their national funding sources are acquiescing in a broader, deeper role for the EC.

For industrialized countries outside Europe, this movement provides enormous incentive for a reassessment of the traditionally overwhelming emphasis on bilateral S&T relations. A policy of

continuing to emphasize the predominance of nation-nation arrangements, while the transfer of strategic planning and coordinating authority flows to Brussels, might appear overly cautious. Yet the pace of change and the final parameters of the S&T structure in Europe are far from established; likewise, the responses of non-EC countries in realigning S&T relations and cooperative activities must be measured and in keeping with the pragmatic realities in Europe. However, long-range analysis points to a collective strengthening of European S&T capabilities, increasingly targeted and led by EC Commission policies and research programs, in close coordination with EC national governments and relying on their resources, manpower and facilities.

As U.S. policymakers begin to define U.S. interests in pursuing a formal relationship with the European Community, there are a number of salient points relating to EC integration and US-EC relations which should be kept in mind. Taken together, they argue for U.S. recognition of the growing importance of Community-level funding, coordination and strategic planning for research and infrastructure support, while highlighting the need to maintain for the foreseeable future a strong pattern of bilateral cooperation with the individual member states.

- The European Community, under the provisions of the Single European Act, has a principal responsibility for stimulating multilateral S&T cooperation among the member states, with the aim of strengthening the scientific and technological basis of European industry;
- Wide variations still exist among EC member countries with regard to R&D investments, quality and distribution of resources, shares of public and private sector funding, and government S&T policies;
- S&T resource levels, information flows and professional mobility all remain below normative patterns in the U.S., despite significant improvements in all these areas in the last half decade, indicating an S&T base not yet as strong, deep or integrated as that of the U.S.;
- Basic research budgets in the major EC countries are relatively stable or rising only slightly; any significant increases in public funding appear targeted to development of technology with commercial potential.
- The U.S. remains (almost universally in the perceptions of European researchers) a very desirable location for study and research, and European S&T administrators believe that U.S. visits by European researchers will remain high in number over the next decade; these administrators, however, are establishing programs to make inter-European exchange visits more attractive and likely alternatives;
- The major emphasis in international scientific exchange for the larger countries of Europe still rests on bilateral programs, and relations with the U.S. continue to be a top priority.
- The declining pool of European researchers and science and engineering students, combined with increasing competition for S&T personnel and emphasis on intra-European mobility, could lead to some decline in the numbers of students and possibly of researchers visiting the U.S.;
- Continued internal EC stalemate over S&T funding levels and Commission autonomy in R&D program management could slow the integrative process, making reliable scenarios for U.S.-EC relations difficult to project.
- Although several principal S&T-performing member states are ambivalent about formal U.S.-EC relations, the integrative momentum favors a growing and substantial international, as well as a multilateral, role for the EC Commission in European S&T. This situation imparts a problem for the U.S. of timing, balance and comprehensiveness in developing an official relationship with the EC.
- The rapidly growing EC focus on Eastern Europe has resulted in substantial policy attention and bureaucratic resources for external cooperation being turned to that region, creating opportunities for joint U.S.-EC S&T cooperative assistance projects.

With a view toward verifying these observations and putting them into the context of current American S&T relations with, and future interests in, Europe, the report will examine:

- European Community-funded S&T programs, policies, and capabilities
- policies, programmatic emphases and capabilities of key member states
- the EC-member state interface: the economic, political and S&T matrix
- the expanding reach of the EC in international S&T
- challenges of European integration for US-European cooperation
- concerns, issues and assessments regarding US-EC cooperative relations

EUROPEAN COMMUNITY S&T: PROGRAMS, POLICIES, CAPABILITIES, INTERNAL RELATIONS AND FOREIGN AFFAIRS

European Community S&T Programs, Policies and Capabilities

Movement toward multinational scientific and technological (S&T) cooperation in Europe has proceeded independently of the rapidly evolving economic and financial integration which is the aim of the EC's 1992 Single Market Plan. However, the progressively strengthened role of the Commission of the European Communities ("the Commission") is providing an umbrella for strategic planning and coordination of resources devoted to that cooperation. The Commission's applied technology programs such as ESPRIT (information technologies) and RACE (telecommunications infrastructure development) have demonstrated, according to many qualified European observers and research administrators, that significant shared benefits can be produced through multinational collaboration. Consequently, the Commission's stock as an efficient manager of R&D is rising correspondingly in both the political arena and the public eye.

Until very recently, the Commission's programs have been directed almost exclusively toward "precompetitive" research, designed to enhance the capabilities of European researchers to further develop it for commercial applications in support of economic competitiveness. The first of these programs was ESPRIT, the European Strategic Program in Information Technology, launched in early 1984. It was designed with the dual purposes of building cooperative research alliances in the information technologies industry in order to boost overall European competitiveness, while also serving as a dynamic model of new approaches to overcoming or dismantling traditional barriers to transnational R&D cooperation within Europe. It remains by far the largest and most costly of the EC research programs, and it has served as model for subsequent cooperative programs in other research fields such as telecommunications, biotechnology, industrial modernization, new materials, and predictive medicine and health care.

Such basic research as occurred under these programs was incidental to the pursuit of technology applications. However, with the adoption in 1990 of the third in its rolling series of S&T umbrella research structures, known generically as FRAMEWORK, the Commission is now broadening its attention to encompass basic science, a category heretofore reserved largely to the EC member states through their nationally funded programs. The Commission has gained approval from the EC Council of Ministers for a major effort over the next five years to promote close cooperation in fundamental research among researchers throughout the EC. In large part this is due to the success of the applied technology programs as models of cooperation and to the increase by each EC member state of both domestic support for applied technology and involvement in EC-wide cooperative activities.

The scale of R&D funding of all types by the Community is still minuscule by comparison with that of member state national S&T programs, even limited to non-defense S&T. The EC's in-house R&D capability consists only of four Commission-run research facilities (The Joint Research Center) employing a total of perhaps 500-600 active researchers. Its FRAMEWORK Programme for strategic management and coordination of Community-funded R&D is a program of contracts and grants to universities, national laboratories and private sector companies, with 50/50 cost sharing from the latter two categories. The actual research and development activities are performed overwhelmingly at member state facilities, employing member state researchers and support staff, using member state equipment. Among the four largest EC countries, public sector civilian R&D spending ranges from eight to seventeen times the total of EC Commission funding for R&D.

The strength of Commission programs lies instead in its objectives and methods for stimulating the collaboration of research entities in a matrix that few national government agencies or multilateral S&T organizations had seriously attempted before FRAMEWORK: transnational, public/private, and industrial/academic. Such successes as these programs have demonstrated, while uneven and not yet sufficiently evaluated, appear to stem from the following characteristics:

- they have focused on advanced technologies with high apparent potential for commercialization;
- they work to aggregate the scientific and technological resources of Europe and encourage synergistic benefits in ways improbable for member states to achieve without supranational coordination; and
- they provide impetus to the lowering of technical and regulatory barriers to competition within Europe, thereby encouraging development of production economies on a par with those of the United States and Japan, reducing the latters' distribution and marketing advantages.

Commission programs have thus accrued leverage far out of proportion to their relative funding weight by directing and coordinating resources in ways designed to stimulate synergistic collaboration and rapid achievement of results. This process tends to level the playing field in Europe for subsequent commercial competition while simultaneously building collective competitive strengths vis-a-vis the U.S. and Japan.

This approach was deemed critically necessary to the recovery of economic health in European advanced technology applications. Between 1979 and 1985, the EC countries collectively showed net declines in exports, both inter-EC and external, in every high tech industry except chemicals and pharmaceuticals, illustrating an economy becoming increasingly dependent on technology development taking place outside of Europe.

The FRAMEWORK Programme of Research Support

The goal of the FRAMEWORK Programme is to establish models for, and to institutionalize the pattern of, cross-fertilization in S&T through coordination of expertise, resources and financing which reside in the member states. The more immediate objectives of the Community-sponsored R&D are to:

- raise the capabilities of European applied technologies R&D to the level of the U.S. and Japan;
- break down barriers to cooperation in research between EC countries, between firms, and between research institutions;
- foster university-industry linkages in basic and applied sciences; and
- encourage the mobility of S&T professionals and equal treatment of professional and academic credentials throughout the Community.

The EC research program for 1987-91, known as FRAMEWORK II, accounts for an average of just over one billion ECU ($1.2 billion @ 1 ECU = 1.2 $US) annually. Along with the in-house expenditures of the Joint Research Center, the total of $1.6 billion represents roughly four percent of total public sector R&D by the twelve member countries of approximately 40 billion ECU (1989 estimate). This comprises only five percent of total publicly-funded *civil* R&D in the EC 12. The EC's own R&D capability is limited; over ninety percent of EC-funded R&D is actually performed through FRAMEWORK at member state public and private sector facilities, using their staff and equipment. As a rule, the EC provides no more than half the cost of any project; the remainder comes from the contract research participants.

For another measure of comparison the EUREKA Program, which is industry-led and independent of the EC, and targeted on R&D somewhat closer to commercializable products and services, has been capitalized since its inception in 1985 at over $8.7 billion, with spending which now approaches $1.5 billion per year. It is obvious that total funding for either Community or EUREKA programs, excepting information technologies (IT), is not remotely comparable with the levels of research spending devoted to their counterpart national efforts.

The FRAMEWORK Programme has been directed initially and predominantly at applied technology research and pre-competitive technology development. By far the largest components of EC-funded R&D under FRAMEWORK II have been telecommunications and information technologies (42 percent); energy research, especially fusion and nuclear safety (22 percent); industrial modernization (16 percent); and health, biological resources and environment (11.5 percent). Only fusion research could have been said previously to embody any significant amount of fundamental science. Under FRAMEWORK III (1990-1994), which was authorized in the spring of 1990, the proportions have changed somewhat, as follows: IT (39%); energy (14%); industrial modernization (16%); and health, life sciences and environment (22%). Additionally, human resources and mobility are brought under the

FRAMEWORK umbrella for the first time, receiving 9% of the total funding.

The Third FRAMEWORK Programme carries the potential for significant qualitative improvements over its predecessor. The second Programme was composed of 37 separate research programs, each of which required discussion and a qualified majority vote in the Council of Ministers before it could be implemented, or more significantly, modified. The effect overall was to rob the program managers and Commission policy makers of initiative once the FRAMEWORK package and its individual programs were initially approved. The success of the Commission in getting the number of programs reduced to fifteen, along with obtaining concessions from the Council pertaining to reprogramming of funds, promises greater latitude to managers in directing resources toward emerging priorities while closing off less promising areas of research.

A major disappointment to the Commission concerning FRAMEWORK III was the ceiling placed on future year funding; the total Programme budget of ECU 5.7 billion ($6.84 billion @ 1 ECU = $1.2) over the next five years, in inflation-adjusted terms, provides virtually no increase over the ECU 5.4 billion allocated in 1987 for the second FRAMEWORK. However, in keeping with the "rolling" nature of FRAMEWORK, there is a two-year overlap with the second Programme, which results in an additional ECU 2.2 billion ($2.65 billion) available for the first two years of the third Programme. That money, however, will fund continuing or already initiated research projects; it will not be available to new starts under FRAMEWORK III.

The Commission has initiated under FRAMEWORK III a larger and more concerted Community effort in basic research. Senior S&T officials in Brussels have indicated that program managers in all 15 categories of the new FRAMEWORK will be encouraged to set aside up to 10% of their program budgets to support fundamental research in science and engineering relevant to their program objectives. Likely fields for such initiative are advanced computing, new materials and biotechnology-related life sciences.

The ground for this advance was prepared earlier, when the Commission in 1989 announced a new component of the information technologies program ESPRIT II to be focused on basic research. Approximately 4-5 percent ($60-75 million) of the ESPRIT II budget through 1992 has been set aside for this area of research activity, which will be performed principally by university and public research institute investigators. It is under the ESPRIT Basic Research Program that the Community's first basic research cooperation with the U.S., beyond nuclear fusion and safety, is moving forward with the National Science Foundation (NSF) and the Department of Defense Advanced Research Projects Agency (DARPA).

S&T Infrastructure-Building

The Commission is involved in several other ways in encouraging a more coherent research environment within the Community. Although member state policies and procedures control participation and procurement in nationally-funded work, the EC is attempting to coordinate the types of local incentives offered to attract and support research with potential commercial utilization. It is also wrestling with the topic of fairness in public procurement, initially by determining whether R&D should be treated as a service or a product.

One Commission program just authorized in late 1990 will devote $300 million in EC funds to an NSF/EPSCoR-type program to develop human S&T capabilities in lesser-developed regions of the Community. Work in the SCIENCE human resource and mobility program, as distinct from the directed research programs in FRAMEWORK, has been focused on securing and promoting freedom of mobility, equality of national treatment, and stimulation of transnational collaborative opportunities for researchers and other professionals throughout the Community. Under FRAMEWORK III, this effort is being expanded with total funding of nearly $600 million for the five-year effort. And finally, the EC is moving toward legislation regulating the importation, transport, and disposal of research materials. All these efforts are designed to level the playing field for competition over R&D resources within the Community.

EUREKA, while not a European Community initiative, is intimately linked to a wide variety of EC programs. It is supported financially by the EC, as one of the 21 members of EUREKA, through participation in EUREKA projects having a pre-competitive character and where there are mutually supporting interests. The EC also contributes to the success of EUREKA projects by way of the evolving framework of institutional mechanisms, the thrust of Community-wide research and training programs, and commitment to the

implementation by 1992 of a single internal market in both goods and human resources. EUREKA contributes importantly to the EC's long-term S&T objectives by providing a forum for cooperation between companies in EC nations and those in the European Free Trade Association countries (Austria, Iceland, Norway, Sweden, Finland and Switzerland) and, increasingly, Eastern Europe.

Policies, S&T Priorities and Capabilities of Key Member States

European Community research activities are tied intimately to national S&T regimes, due to two major characteristics attaching to Community endeavors. First, the European Community is effectively the twelve member countries acting collectively, and it is also the EC's governing institutions, which are all representative of but to a large degree independent from the member countries. Secondly, Community-level S&T is organized, funded and managed from Brussels, but is conducted overwhelmingly through contract research that is actually performed at facilities, and by researchers, located in individual member states and thus responsive primarily to national government influences.

This first characteristic inherently produces potential for conflict, among member states with their differing sets of S&T priorities, and between the EC's governing entities (the Council of Ministers, the Commission, and the Parliament) and various of the member state governments. Since unanimity in voting is required to determine the broadest and most important policy-level decisions affecting Community undertakings, such as the passage of the FRAMEWORK Programme, the notion of a "Community" S&T policy is much more ambiguous and subject to flux than are the S&T policies and priorities of individual member states.

The second characteristic means that, the Commission's own limited research facilities excepted, the EC S&T program is carried out at the national level, by private firms, national labs and universities that - not infrequently - are conducting parallel R&D activities on behalf of their national governments or for national markets. Thus EC support for collective S&T can be viewed from one perspective as a partial pass-through mechanism for research programs that are underwritten by the member states as adjuncts to their own, and in many instances much larger, national research programs. However, EC research program management and strategic S&T policy planning, by focusing on overcoming or reducing transnational barriers to cooperation, are serving to influence and align the development of a variety of national research and development priorities.

The EC programs, with increasing effectiveness, are combining "top-down" identification of strategic research objectives and macro-level planning for collaborative resource utilization with "bottom-up" proposal competition by a variety of investigator teams. The latter are being encouraged by their national governments (which in many cases provide research overhead support through salaried employment, ownership of facilities and/or state procurement policies) to participate in multinational European R&D. The primary objective, aside from recouping national tax monies going to the EC, is to gain advantages from the synergistic effects of research collaboration and in no small way to strengthen the *national S&T infrastructure* and the economic competitiveness which it stimulates.

Thus, an assessment of European Community S&T cannot be meaningful apart from a comparative understanding of the S&T capabilities, structures and priorities of the EC member nations, over which EC-funded research is layered as an integrative device. A detailed review of primary indicators of R&D performance of the five principal S&T performers in the EC is included in the following descriptive charts. However, some generalized observations on national S&T efforts are valuable to highlight areas of divergence from and harmonization with the EC programs.

The Importance of the "Big Three" Members

- *EC R&D performance is overwhelmingly dependent on Germany, France and the United Kingdom, with Italy and the Netherlands adding significant contributions to public, civil expenditures.*

The top three EC countries in R&D expenditures (Germany, France and the United Kingdom) account for over three-quarters of the total attributable to all EC members. The total figure for those three in 1988 (using constant 1982 dollars) is just over $49 billion (closer to

$60 billion in current dollars), or almost half that of the U.S. Public sector R&D spending of $25 billion annually is again almost half that of the U.S. However, public sector *civil* R&D expenditures for the three total $15.5 billion, which is around 60% of the corresponding U.S. figure. Adding public civil R&D for Italy and the Netherlands brings the total to $21.5 billion, or roughly 85% of the U.S. total for that category (still using constant 1982 dollars).

The importance of this fact is that the top three countries are the predominant factors in resources, revenues, expenditures, policies and planning associated with Community S&T. No Commission-funded activities can emerge without the solid backing of at least two of them. Moreover, these are the countries within which the Commission-funded programs are implemented, because the majority of Community capabilities and resources reside there.

Lack of Commonality in National R&D Activities

- *There is no consistent pattern of policies, planning or organizational structure for public sector S&T among these five countries.*

Generally stated, the United Kingdom and the Netherlands have strongly emphasized increasing the level and proportion of private sector R&D spending; however, the UK stresses that non-defense, public sector support should go overwhelmingly to basic research, while the Netherlands has stressed public support of industrial technology development. On the other side of the fence, France and Italy have both supported a predominance of public sector spending in national R&D; yet French government funding has been moving toward technology development, while Italian support has emphasized basic research increases. Germany has opted for strong encouragement of private sector R&D (the highest percentage in the EC), yet attempts to balance public funding for both applied technology and basic research.

France, and increasingly Italy, are emphasizing use of public funds for large-scale human resource development to meet a rapidly approaching dearth of scientists and engineers in those countries. Germany has not until very recently acknowledged a need for public intervention in this area, while the Netherlands appears to see a sufficient supply on hand for its needs. The UK government has for several years largely avoided dealing with an acknowledged, rapidly worsening crisis in both availability and quality of young British researchers.

In the area of defense spending, half the British public budget goes to military R&D, overwhelmingly in development. One-third of the French national budget is devoted to defense R&D, and the proportion has been rising. Germany spends a declining 12.4%, Italy 8.5% and the Netherlands only 2.6%. Collectively, the proportion of EC public R&D going to defense is probably somewhat less than 25%.

The organization of public S&T policymaking varies considerably among these countries: a loose, collegial and well-functioning structure in the Netherlands; a loose, fragmented and not well-coordinated one in Germany; effective centralized policymaking aligned bureaucratically with centralized operational responsibilities in France; tightly centralized policymaking in the UK combined with a loose and collegial operational bureaucracy; and in Italy, a transition from the absence of an S&T ministry, with a highly fragmented policy and operational structure, toward a new and potentially large and highly centralized S&T ministry and policy structure.

The overall picture is one of a highly diverse grouping of S&T performing countries that lack sufficient commonality to engage effectively in a loosely confederated structure for policymaking, coordination or strategic planning of multinational S&T. Thus, the opportunity is present and obvious for a major EC Commission role in performing these functions.

S&T Growth As a National Priority

- *Substantial efforts are being implemented in all of these countries to upgrade quickly their resources, capabilities and planning for S&T.*

The percentage of gross domestic product (GDP) devoted to R&D is above 2.3% in four of the top five. Although Italy's ratio is only 1.5% (1987), it has doubled since 1980, and reaching equivalence with France and the UK by 1992 is an identified national priority. This compares with a U.S. figure of 2.8% (of which at least one-fourth goes to defense).

Support for basic research ranges from 15% to 20% of the national budget among the top five; however, only in Italy is the trend upward in both rate of growth and total expenditures. However, pressures at the national level to funnel substantial additional support to S&T infrastructure building and to applied technology

development for economic competitiveness is squeezing funding for basic research. This situation has created an expanding opportunity for the EC Commission to move into the area of basic research coordination and support, in conjunction especially with new research fields which the chief member states are insufficiently prepared to underwrite.

Constraints on Public Funding Choices

- *The ability to increase or reallocate discretionary funding to support promising and emerging science and technology is constrained in all the major member states, providing increased leverage to EC Commission programs and funds.*

Commission funds support only the actual costs of specific R&D. Not only can they be targeted selectively, but they can be reprogrammed as often as the FRAMEWORK Program is revised. Conversely, the vast bulk of national R&D budgets is committed to salaries of R&D personnel in public employment, to facilities and equipment comprising public physical R&D infrastructure, and to long-term support of a wide range of traditional R&D undertakings. This leaves relatively small portions of national S&T budgets available for new multilateral S&T undertakings or for new, cross-disciplinary research. Hence the role of EC member states in launching and supporting R&D undertakings that break new ground - whether to carry out policy, to pursue emerging research fields, or to build and adapt organizational structures to new demands - is constrained. In this manner, the overwhelmingly greater S&T capacities of the key member states, vis-a-vis the EC Commission, are less disproportionate to those of the Commission in devising initiatives relating to next-generation, cutting-edge research.

Shedding light on these generalizations about EC member state S&T characteristics are some "shorthand" characteristics of the individual countries, taken largely from an unpublished NSF report entitled "Policies, R&D Priorities and Capabilities of the Key EC Member States," (NSF/INT, 1990).

OUTLINE OF KEY EC MEMBER STATE S&T CHARACTERISTICS

Chart 1: *Federal Republic of Germany:*

- ☐ public sector S&T policymaking and operational authority is loosely shared among the following: BMFT ("big science," international cooperation, non-university technology development, support of quasi-public R&D institutes); MPG, FhG, and DFG (basic sciences support, general university research, funds for quasi-public research); and the Lander (support to small-and-medium enterprises, innovation, university R&D, technology development);
- ☐ the FRG has the largest S&T expenditure among EC member states, $24.6 billion in current 1988 dollars; for 1989, in current dollars, the figure is $26.6 billion;
- ☐ the BMFT budget is growing at nearly twice the rate of the entire FRG budget;
- ☐ a high percentage of FRG S&T budget goes to basic research (20%)
- ☐ there exists a long-standing policy of encouraging private sector-performed, privately-funded, market-driven technology development
- ☐ a very low proportion of national budget is spent on defense: 12.5% in 1986 (up from 12.4% in 1986);
- ☐ the R&D budget is 4.2% of the total national budget (1986)
- ☐ a high proportion of GDP is devoted to S&T: 2.85 % in 1989 (up from 2.8% in 1988 and 2.7% in 1985); the EC average is just over 2.0%
- ☐ Priorities are:
  - advanced technologies development;
  - increased international cooperation;
  - improvement in conditions for R&D in SMEs;
  - maintenance of support for basic research; and
  - focus on preventive research.
- ☐ Industry funds 65% of all R&D (1989); the trend is upward
- ☐ Basic research is funded 50/50 between the Federal government and the Lander; funds go through the research societies and also directly to universities
- ☐ 13% of basic research spending goes to engineering
- ☐ national R&D spending has experienced a 3.7% real, adjusted growth during 1985-88.

Chart 2: *France*:

- ☐ authority for civil R&D is centralized in the Ministry of Research and Technology (MRT). All publicly funded civil S&T activities fall under its policy umbrella, with shared roles by Ministries of Education, Industry, Economy and PTT (for space);
- ☐ France has the second largest EC S&T expenditure, at $17.5 billion in constant 1988 dollars; the figure for 1989, in current dollars, is $19.1 billion;
- ☐ industry funds 43% of total R&D (1988); there has been a slight upward trend over the past decade;
- ☐ roughly 20% of total S&T goes to support basic research.
- ☐ research is designated a national priority, emphasizing enhanced support for industrial research; young researcher training and employment; increased public support to small-and-medium enterprises;
- ☐ national R&D expenditures are growing at a rate of 6.5% annually (3.4% real adjusted growth 1985-88);
- ☐ 8% of basic research spending goes to support engineering research;
- ☐ the R&D budget is 6.34% of total national budget (1986);
- ☐ a modest proportion of GDP is devoted to S&T: 2.31% in 1989 vs. 2.25% in 1985; the trend appears to be upward;
- ☐ 31% of budget goes to defense R&D in 1989, against 34% in 1987.

Chart 3: *United Kingdom*:

- ☐ policymaking for S&T is centralized in the Prime Minister's office; the bulk of funding flows through the Departments of Trade and Industry (technology) and of Education and Science (basic research);
- ☐ the UK has the third largest EC S&T expenditure, $17.1 billion in constant 1988 dollars; the figure in 1989, for current dollars, is $17.8 billion;
- ☐ Industry funds 50% of total R&D expenditures in 1989, up from 47% in 1988;
- ☐ R&D expenditures have grown at over 7 percent annually in recent years (4% real adjusted growth 1985-87);
- ☐ a high percentage of budget goes to defense R&D: 47% in 1989 (51% in 1987);
- ☐ 17% of the total national S&T budget (35% of civil S&T) is spent on basic research (1985);
- ☐ Research Council and university investigators perform 95% of basic research;
- ☐ there has been a sharp decline in government funding of industrial R&D, from 30% to 20% in the five years prior to 1986;
- ☐ Priorities are to:
  - maintain and enhance S&T education and research quality;
  - increase social and economic return on S&T investment; and
  - improve management for greater concentration and selectivity of support
- ☐ the R&D budget consumes around 3% of the national budget (1986);
- ☐ The portion of GDP to R&D is relatively modest: 2.17 % in 1989 vs. 2.21% in 1988 (2.25% in 1985); the overall trend continues downward.

Chart 4: *Italy:*

- ☐ policy and operational control has been centralized very recently in the Ministry for University and S&T Research; the bulk of funding supports CNR (basic & precompetitive research), ENEA (energy and technology development) and the new Space Agency.
- ☐ Italy has the fourth largest EC S&T expenditure, $10.0 billion in constant 1988 dollars; the figure for 1989, in current dollars, is $10.0 billion;
- ☐ industry funds 42% of total R&D, a recent reversal of a long downward trend;
- ☐ an extremely low percentage of the national budget goes to defense R&D: 8.5%
- ☐ Priorities:
  - increased funds for new technologies research
  - increasing overall level of govt and private R&D expenditures
  - decreasing support for nuclear electric power development
  - parity by 1992, in GDP ratio for R&D, with UK and France
- ☐ the percentage of GDP devoted to R&D is low by standards of industrialized countries: 1.25 % in 1989, down from 1.4% in 1987 but up from 1.12% in 1985;
- ☐ the percentage of national budget spent on R&D was 1.6% in 1986;
- ☐ Italy's annual growth rate in S&T spending was 12-13% during the 1980's (12.2% real adjusted growth 1985-88);
- ☐ basic research averaged 15-16% of total R&D expenditures during the early 1980's, and 34-36% of the national budget for R&D;
- ☐ there have been large recent increases in contributions to European-wide R&D programs.

Chart 5: *Netherlands:*

- ☐ policymaking and operational direction of S&T are decentralized through several advisory bodies (RWT is predominant) and two government ministries, Economics and Education & Science;
- ☐ the Netherlands has the fifth largest EC S&T expenditure: $4.4 billion in constant 1988 dollars; the figure for 1989, in current dollars, is $4.9 billion;
- ☐ industry funds 55% of total R&D (1989); the trend is strongly up, from 50% in 1985 (70% of this portion is performed by five multinational corporations);
- ☐ the portion of GDP devoted to R&D is 2.38%, strongly up from 2.11% in 1985 and from 2.03% in 1980;
- ☐ there has been an annual rise of 8.4% in total R&D expenditures over past several years; (5.3% real adjusted growth 1985-88)
- ☐ basic research averages 18% of national R&D budget;
- ☐ an extremely low percentage of budget goes to defense R&D: 2.6% in 1988.
- ☐ Priorities are to:
  - stimulate innovation and R&D performed by SMEs
  - increase funding for advanced technologies R&D (IOPs)
  - decrease government sector R&D and encourage market oriented R&D

The EC-Member State Interface: The Economic, Political and S&T Matrix

Europeans by and large consider the evolution of the Single Market to be an assured process. The relevant question is how soon and how extensive will it be and how pervasive in its operation. In most economic and financial matters, the real arguments are over how quickly to press for the diminution of national powers and the harmonization of national statues and regulations. Close intra-EC cooperation in S&T matters is rapidly unfolding as an integral component of the larger scheme of integration. Science and technology are seen increasingly as the keystone of future economic competitiveness and, hence, the glue which will hold together the economic integration on which a unified Europe will be built. The dimensions of this new paradigm are far from clear to many of the principal European policymakers, who themselves seem at times overtaken by the pace of events.

An Expanding Concept of Integration

Until the adoption of the Single European Act, economic integration was viewed by many, in Europe and abroad, primarily as an internal process not closely linked with tangential political, social or foreign affairs issues. These were regarded as outside the political or legal "competence" of the Community, in the context either of relations among EC member states or of "external" relations with non-member countries. The requirements for successful economic integration, however, have forced a re-evaluation of that supposed independence. Increasingly, the deliberately ambiguous language and deftly vague extensions of "competence" embodied in the Single Act are read as an acknowledgement of the very real linkages which tie economic harmonization to social, environmental, financial, military, foreign policy, and S&T concerns and obligations.

Apart from economic union, other major integrative pushes have appeared in the past two years, notably the drive for acceptance of European Monetary Union (EMU) and its Exchange Rate Mechanism (ERM); growing demands for a common social welfare and labor policy; emergence of a collective EC role, representing Europe, in international affairs; and most recently, the nascent initiatives for political union and Community military security planning. While these efforts to unify the twelve countries of the EC in functionally oriented ways are held to be separate, their close kinship has been attested to in the past six months by senior officials on both sides of the Atlantic.

Such sentiments bring to the fore two salient aspects worth consideration in the larger matrix. The rapid evolution of modern economic and social systems has come to depend on the benefits produced by research and technology development. Conversely, research and technology development needs have surfaced in linkages to other, formerly quite distinct areas of public policy such as education, manufacturing and commerce, finance and investment, national security, health and social welfare, and transportation. It is this web of interdependent "raisons d'etre" of government which is now confronting the Community in its recognition that economic integration is the foundation not simply of European cooperation, but of a complex new architecture of relationships. Seen in this light, cooperation in science and technology is both a dominant component of strengthened European competitiveness *and* a subordinate concern in the overall calculus of a fully integrated Europe that possesses multiple roles in the larger scheme of international relations.

The Challenge of German Unification

Until the early fall of 1989, the direction of S&T integration in the EC was fairly predictable; only the pace and timing were at issue. That orderly, planned progress has been upset by the political revolution in Eastern Europe. Earlier planning for EC integration has been undergoing continual revision throughout 1990. In this climate, planning for science and technology is subject to rapid change and is increasingly vulnerable to redirection of resources. The principal causes of this new instability in S&T go to the heart of what European integration portends.

Foremost is the challenge of German reunification. It has been widely supposed that West Germany's commitment to the EC has been predicated on the existence of fundamentally opposing political and economic systems in Western and Eastern Europe, sustained by superpower confrontation. However, the larger equation—politically and economically—has changed almost overnight. Communist economic and political hegemony in Eastern Europe has rapidly dissolved into diverse societies whose common characteristics embody trends that are, loosely,

democratic and market-oriented. Moreover, Soviet political and military domination of those countries has dissolved equally rapidly, along with the East-West confrontation which justified the Atlantic orientation of the European Community.

The political unification of Germany occurred on October 3, 1990, and economic integration at a practical level had been moving ahead full steam for the previous year. Germany is certain to experience short-term social and economic dislocations as a result. The cost over the next five years of rebuilding eastern Germany has been estimated at over 700 billion dollars, and both political and business leaders will be necessarily preoccupied with internal problems and their solutions. At the same time German economic growth, already doubling the rate predicted for 1990, will be fueled by the reconstruction needs of eastern Germany. Assuming the restoration of oil price stability near the level antedating the invasion of Kuwait, German economic growth will most likely continue to lead that of other EC members. A serious issue for the rest of the European Community during the remainder of the decade is how to accommodate a Germany whose population, market and economic power will overshadow any other member of the Community, but whose leadership will likely be preoccupied overwhelmingly with domestic concerns.

The Nature of Community: Deepening vs. Broadening

A second source of uncertainty in S&T planning derives from broader internal disagreement in the EC on overall strategic policy planning. Within the past two years, a dispute has emerged within the Community over the general character of the EC in the post-1992 period. One faction, led by France, has advocated a "deepening" of integrative processes, designed to bind the members of the Community tighter in mutual interdependence, while devolving considerable sovereignty over economic and political policies to Community institutions. At the same time, inclusion of additional members in the EC would be delayed for up to a decade.

This movement has been opposed by a smaller bloc led by the United Kingdom and the Netherlands. This "broadening" faction would favor restricting the power and sovereignty of the EC government, granting it only enough to implement and enforce the Single Market directives and a loose type of monetary union. Their major argument stresses the need to "broaden" the Community's aims, influence and Single Market advantages to other nations in Europe whose political and economic systems are compatible with those of the Community. The nature of individual countries' association with the EC would be somewhat flexible, implying a sort of confederation where members would have varying degrees of rights and obligations. The obvious appeal of this argument is that such a system would provide for a quick and relatively easy inclusion of EFTA countries and the gradual absorption of most Eastern European nations, while simultaneously limiting the growth and exercise of centralized authority by the EC governing institutions.

The Germans have played an active role of arbiter in this growing dispute, taking middle-of-the-road positions generally favorable to greater cohesion within the EC. Now that German attention is riveted on its own unification and the needs of its closer eastern Europe neighbors, and with the most creative German talents focused on new opportunities in that direction, a continuing rift within the EC could make movement toward full integration less predictable.

Aid to Eastern Europe Strains EC Commission Resources

A third potential source of instability in S&T integration lies in the EC's commitment to assist Eastern Europe with a variety of economic and technical needs. On behalf of the 24 wealthiest, industrialized nations ("G-24"), which are analogous to the Organization for Economic Cooperation and Development (OECD), the EC has taken the lead in strategic planning and coordination of assistance to East Europe. It has moved swiftly to take advantage of the unexpected opportunity to wield influence in the shaping of a new Europe. Among the potentially effective tools available for "leapfrogging" the wide East-West gap in industrial capabilities and market potential is technology transfer. However, the opportunity carries a requirement to focus attention on external affairs at a critical time in the implementation of the 1992 Plan. Issues associated with the next phase of integration are said by European officials to be getting far less than full attention, the result of EC efforts to address even minimal needs in Eastern Europe. Those needs will grow tremendously in the next several years, if democracy and market mechanisms take root successfully, and the Commission could become hard-pressed in tackling them with the limited personnel and funding it has available.

Integration has created a variety of issues around the establishment of EC external economic and political relations, as well as uncertainties in the maintenance of bilateral relations between the member states and non-EC nations. The Commission has established three priorities, geographically-based, in turning its attention to these matters. Its longest-standing relationships have been with the countries of the European Free Trade Association (EFTA), Western and Central European countries with democratic traditions and market economies. The form of their relationship to the EC requires the most urgent attention. Next in priority are the countries of formerly-communist Central and Eastern Europe, more to support political and economic restructuring in those countries than in expectation of significant short-term market advantages to be gained. In third priority relative to S&T concerns, though admittedly of greater significance, the Commission has placed the formalization of relations with the U.S., Japan and other non-European industrialized countries. Extension of modest EC efforts among the developing countries is unlikely to receive substantially increased attention.

The European Free Trade Association and Expansion of the EC

The EFTA countries [Sweden, Norway, Finland, Iceland, Austria and Switzerland] since the early 1960's have formed a loose trading bloc whose viability appears increasingly vulnerable as the primary characteristics of intra-European and international commerce are being transformed. The maintenance of "neutrality" in the East-West struggle, long a primary consideration for all but Norway, is no longer a serious issue. Austria has already submitted a formal application for EC membership, on which the EC has deferred action until after 1992. The Swedish government appears to be on the verge of making its own application, while the issue of membership has become a political hot potato in Switzerland, giving rise to vocal public debate. In all the EFTA countries, the anticipated advantages of the Single Market to those in it, and the costs of exclusion, are beginning to cause serious anxieties.

The issue of new members for the Community is not a one-way path, however. The dominant mood among Community officials and most member state governments is that the Single Market must be implemented as planned, and allowed to coalesce and mature somewhat, before any new members can be accommodated. As a palliative, the Community is working closely with the EFTA nations individually in their efforts to realign their economic policies, along with the pertinent legislation and regulatory statutes, to link them to the Single Market. This has resulted in rather desultory talks to create a "Common European Space" that would somehow provide consultative access to EC institutions for EFTA countries in matters of legislation and executive policy.

The EC-EFTA relationship has demonstrated not only flexibility in moving toward the Community's goal of a united Europe, but also the dilemma of having to pursue cooperative and harmonizing policies externally, well in advance of attainting either the form or substance of a truly integrated internal market. The resultant impasse in extending the geographic inclusiveness of the EC *within Western Europe* has proven an obstacle to resolving other, equally pressing and important, external affairs issues. Thus, in matters of S&T cooperation with non-EC countries, and despite a high level of interest among EC officials in instituting such relations formally with the U.S., Japan and other nations, the initiation of that cooperation is presently hobbled by existing ambiguities and constraints regarding progress on the full integration of Europe itself.

The continuation of that situation is becoming more untenable with each passing day, however. German reunification, and the de facto incorporation of the German Democratic Republic into the EC, has forced Community politicians and the Member State governments to recognize that the EFTA problem must be removed quickly. The EC is finding it politically awkward to justify accepting the former Warsaw Pact country into the Community, and negotiating increasingly close ties to the rest of Eastern Europe, while continuing to exclude other West European nations from full participation. The nature, geographic extent and philosophical base of the EC are all being hurriedly re-evaluated, upsetting the patiently crafted balance of interests heretofore dominating the legislative and regulatory agenda of the Community.

Technological Assistance to Eastern Europe

The nature of political and economic changes in Eastern Europe and the USSR, especially since late 1989, has presented the EC with unprecedented opportunities, as well as a number of awkward problems. After many years of rebuffing the Communist countries' efforts to open relations with the Community, the EC over the past two years signed mutual trade and commercial cooperation agreements with Hungary, Poland, Czechoslovakia, Bulgaria and the USSR. These agreements are general in substance, providing umbrella authority to engage subsequently in discussions on specific types of cooperation. However, negotiations are in progress with the new governments of Eastern Europe to reaffirm and revise those agreements, specifically to include mutual scientific and technological cooperation.

Perhaps more importantly, the EC was charged by the G-24 countries in mid-1989 to take the lead in organizing Western economic and financial aid to Eastern Europe, as the latter undertakes the painful process of reorganizing its economies for a market-driven orientation. The EC's mechanism for administering aid provided by the G-24 countries is known as PHARE; the transfer of technological know-how has been identified as a component of that assistance. The Community is thus in the forefront for assessing the positive aspects of East European development on the future European economic and security environment, as well as meeting the challenge posed by change and turmoil to the east.

The extension of favorable trade terms, capital for industrial restructuring, and technology sufficient to make East European products and services competitive in Western markets is considered imperative by many in the EC to underwrite political democracy. Their absence will risk the collapse of indigenous efforts by Eastern Europe to evolve toward the Western political and economic system (and implicitly, risks the reimposition of authoritarian rule). Yet the introduction of market-oriented industrial production and services methods is severely handicapped by the absence of an advanced technological and managerial infrastructure to implement those methods or utilize the available technologies.

The Challenge of Japanese Technological Dominance

A very present worry to Europeans for most of the last decade has been the threat of eventual Japanese dominance of European markets, in both capital and consumer goods. A variety of means have been attempted by individual nations to protect certain industry segments against that threat, including quotas, anti-dumping legislation, and local content requirements, all with limited success. However, the observed tendency in European Community is to move forward—albeit haltingly—on its pledge to implement a market-driven economy and free trading system throughout the EC. Consequently, national barriers targeted selectively and primarily against the Japanese have begun to crumble.

Designed in part to offset the looming window of vulnerability to Japanese goods (and, by extension, U.S. products), the Commission has instituted a restrictive policy for participation in Community-funded R&D. Companies, or "legal entities," qualify for participation in EC-funded research programs *only* if they are "European Community" entities, meaning a company must maintain an "integrated presence" in the Community encompassing a triad of R&D, production and marketing/service facilities. Nevertheless, a significant number of the larger Japanese firms are already moving to overcome this restriction and have expanded their previous production and marketing operations in Europe to incorporate R&D facilities.

The willingness of the Japanese to make this commitment to European operations, along with the equal willingness of major EC-based corporations to enter joint ventures with Japanese firms or to acquiesce in Japanese takeovers of smaller European competitors, has given serious alarm to strategic economic and S&T planners in the EC and the member states. The successful encroachment by Japanese firms on the emerging Single Market has made the Commission and its allies in the member state governments dubious about the feasibility of creating a protected environment for European firms in advanced technologies. The situation is also prompting concern in some quarters, particularly relating to pre-competitive research, that the Community needs to ensure continued open access to American S&T. The concern has extended to Commission initiatives to solicit American participation in the *basic research* end of Community-funded programs on an equal basis with participants from EC Member States.

Limits on the Community Role in External S&T Relations

The Single Act removed much of the earlier ambiguity over the extent of EC legal and political "competence" in both non-economic matters and foreign relations. The range of matters subject to EC purview, including specifically science and technology, has been vastly expanded. Additionally, the purposes of such undertakings to some extent can be pro-active or future-oriented and only tangentially related to current, internal EC business. As importantly, the Commission has obtained blanket approval from the Council to initiate discussions with non-member countries on a wide range of topics. Specific approval is still needed from the Council, however, to actually negotiate formal agreements that are binding on the member states.

It is with this recently-found latitude that the Commission has involved itself so intensely in pursing agreements with the EFTA countries and those of Eastern Europe. Particularly in the realm of science and technology cooperation, however, this extension of the Commission's powers and influence has proven contentious. For although the Commission's mandate in S&T matters extends unarguably to *applied technology development*, in support of international competitiveness, some of the most promising areas of international (eg., external to the Community) cooperation lie in basic research and in S&T training and mobility. The Commission is not likely to advocate significant cooperation with the U.S. or Japan, or indeed with any non-EC state, in applied technology fields where the Community is seeking to promote its competitive position vis-a-vis those countries. The member states strongly underwrite this view, and there seems to exist an uneasy modus vivendi with the Commission over the extent of Commission autonomy in this area.

Commission programs in applied technologies have received the support of the Council of Ministers and the member states they represent largely because these programs are demonstrating how to organize and promote research in ways and in scope difficult to implement at the national level. The Commission offers the prospect of managing European S&T on a basis un-restrained by narrow focus, voluntary membership, statutorily-limited authority, small-or-declining financing, or inadequate organizational capabilities. Consequently, as successes are gained, the impetus is to extend the range of research coordination.

It is at this point that member state support becomes uncertain, for potential Commission direction and funding of fundamental science puts the EC squarely into an arena heretofore reserved to national governments. The sphere of basic research is one of the last remaining areas of national sovereignty to be pulled into the momentum of integration, and for several member states it has become a symbol of the struggle to maintain national identity, as well as policy and budgetary control over national resources. Moreover, basic research is something which member states have fostered successfully on a national basis and which they have a deep stock of expertise in supporting and managing. For this reason, the prospect of a basic research function lodged in the Commission has encountered some resistance. However, as the national governments continue to shift their domestic priorities and resources increasingly to applied technology work, without significantly increasing their overall civil S&T budgets, that same prospect is appealing to other, generally the smaller, EC members.

What these reactions seem to point to, though not directly or clearly, is that the dominant EC member states wish to retain a pre-eminently bilateral pattern to European cooperation with the U.S. in S&T. They are not opposed to the establishment of a Commission capability to represent the collective interests of the Community in areas recognized as requiring multilateral or global involvement (eg., environmental protection, disease control, preventive medicine, global warming). Yet many EC members officially support and desire continuance of a system of independent, bilateral S&T relations with non-members, apart from the momentum of integration in all other areas of Community activities. It is unlikely, however, to do more than slow the evolution of a predominant Community umbrella role in strategic research planning and in coordination of resource development and allocation.

EUROPEAN COMMUNITY S&T: INFLUENCES ON U.S.-EUROPEAN S&T COOPERATION

Challenges for U.S. Policymaking

Scientific and technological vitality are increasingly viewed in Europe as critical catalysts of economic growth and well-being. Consequently, the majority of the EC's member governments have been willing increasingly, albeit reluctantly, to relinquish traditional notions of sovereignty over S&T matters, as they have done previously in economic affairs. The U.S. is thus presented with a pressing need to develop a coordinated response to the evolution of a Community-level S&T structure for policy and research programs. Yet almost no U.S. government agencies, including the National Science Foundation, have substantial knowledge of or experience with EC programs, having focused their efforts heretofore on bilateral cooperation with indivi-dual countries or research field-specific organizations like ESA or CERN. Decision making is further handicapped by uncertainties, equally prevalent in Europe, over the extent to which future progress in S&T cooperation will be coordinated and centrally-planned from Brussels, or *ad hoc* and directed informally by national governments.

Several challenges to U.S. policymaking stem from this situation. The first is one of accuracy in U.S. perceptions of the nature, intent and scope of S&T integration in Europe. Current analytical resources and mechanisms are inadequate to provide extensive and reliable information or assessments on individual countries, research fields or overall European capabilities and resources in S&T. Thus it is difficult to make comparisons of these areas, either with corresponding U.S. research capabilities or with the policy objectives and claimed accomplishments of European multilateral programs, particularly within FRAMEWORK or EUREKA.

The second challenge involves a resolution within the Federal government of different views on how best to utilize U.S. influence on European S&T evolution. The question remains open in most quarters of how far to proceed in developing a relationship with the EC which, *de facto*, lends support to European multilateral S&T. The question is posed against a concensus emphasizing the continued predominance of bilateral cooperation with the member states. Looming over this is the more elusive issue of whether openness and cooperation in international research can be maintained and strengthened independently of the often-conflicting interests of trade and commercial competitiveness.

Another challenge is that of resource allocation policy. Given a consensus that recognizes a growing role in European and international S&T for the Community and other European multilateral organizations, the U.S. will be confronted with decisions on measures and mechanisms to support effective collaboration in a multilateral research environment. Participation to any significant degree will further stretch or bring about redirection of U.S. resources devoted to bilateral international cooperation, which by some estimates are already inadequate.

These issues are complicated by uncertainty and some skepticism over whether centrally-guided and administered, multilateral S&T will actually become a reality in Europe. The evidence is far from conclusive that the kind of synergy evolving in Europe in the microelectronics field will characterize other research fields as well. Yet evidence is abundant of an evolution toward some sort of strategic framework for the multilateral, interdependent utilization of S&T resources. For U.S. policymakers, there is a growing realization that the U.S. is already a principal factor in this process, the final form of which is not much clearer in the capitals of Europe than in Washington.

A U.S. Response: Major Issues and Assessments

U.S. Government S&T Relations with Europe

Concern: The research environment in Western Europe is changing rapidly in ways that may make it necessary, or at the least propitious, to extend United States-European cooperation in S&T, formal and informal, to include the European Community in a collective sense and the EC Commission bilaterally.

Issues: How should the U.S. government respond to EC proposals for cooperative activities in specified research fields? What level of official cooperation would best serve the interests of the U.S. research community? Should the NSF pursue an agency-to-agency level agreement with the EC directorates-general for research and technology development? How can NSF utilize the newly-established US-EC Joint Consultative Group on S&T in stimulating more cooperative actvities among US and European researchers?

Assessment: US-European S&T Relations and Factors Promoting Change

The U.S. government has a variety of longstanding bilateral and cooperative arrangements with European Community member states—113 at present, according to the Department of State. They range from formal, umbrella S&T agreements to informal arrangements with specific government agencies in narrowly-defined fields. Nearly two-thirds cover cooperation in nuclear energy, nuclear safety, and space and aeronautics. By contrast, the U.S. has fifteen multilateral agreements: six with the EC, eight with the European Space Agency, and one with EURATOM. NSF has two bilaterals, with Italy under an umbrella S&T agreement, and an MOU with the French CNRS. It has none with European multilateral entities. Existing relationships are characterized by freedom of personnel and information exchange and openness in joint or cooperative research endeavors. These ties are not directly related to either the EC's 1992 Plan or the Community's FRAMEWORK Programme and would not seem to be immediately affected by them.

However, a growing "European spirit" among young researchers, abetted by a public mood strongly supportive of European integration, points to increasing pressure on national research administrators for incremental reallocations of research resources to, or in parallel with, Community-wide undertakings: grants, fellowships, equipment, travel costs, and other "concertation," or infrastructure support activities. Moreover, a steady rise in effectively-leveraged Commission funding, at a time when most member states' strained financial resources for S&T are directed increasingly to technology applications, will provide additional incentives for intra-EC laboratory "twinnings," joint research projects, faculty exchanges, and other cooperative activities. This situation will have potential for a gradual lessening of commitment by some member states in maintaining current levels of sponsored S&T interaction with the U.S. research community.

If member state S&T policies emerge which give preference, in some areas of research support, to activities in which participation is restricted to Community entities, it would certainly have a negative effect on formal cooperation with the U.S. government, as well as on opportunities for U.S. firms which do not meet the requirements for an "integrated presence" in Europe. Finally, an EC-led emphasis on organizational aggregation—for strategic planning purposes—of European research conceivably could also precipitate a decline, or incorporation into the EC umbrella program, of the variety of non-EC multilateral activities in which U.S. researchers currently cooperate or participate. While this last possible consequence is not likely in the near future, it should not be ignored.

Regarding formal U.S.-EC relations in S&T, opposition within most parts of the EC Commission appears to have evaporated in the past year. Moreover, the Council of Ministers has exhibited a growing interest in external S&T relations, as evinced by its recent request for Commission discussion papers on relations with Eastern Europe and with third (ie., non-EC) countries generally. A stream of signals has been emanating from senior levels in Brussels promoting dialogue on US-EC S&T relations, leading ultimately to a formal agreement, which seems to be the real aim of Vice President Pandolfi's proposal for a joint US-EC Joint Consultative Group on S&T. Even those member states who are still resistant to a formal US-EC agreement on S&T admit to the need for a single,

Community-wide voice to represent members on some types of S&T issues with non-EC countries.

Answers to several still unresolved questions will determine in large part whether, at a what level, an agreement with the EC would be justified by the interests of the U.S. research community:

1) to what extent does (will) the Commission have the political authority to represent member states on collective policy and resource allocation matters, apart from the Commission's own research programs;

2) to what extent does (will) the Commission support research programs or activities that would be comparable in kind and quality to those of the U.S.;

3) to what degree would cooperative activities involve free and open, as opposed to restricted, access by research participants; and

4) will the Commission have meaningful funds at its disposal to support jointly-undertaken or -sponsored research?

These questions should, and almost certainly will be explored soon via the newly-established Joint US-EC S&T Task Force.

U.S.-EC Human Resources: Supply, Education and Mobility

Concern: The centripetal effects of European economic and S&T integration, combined with increasing demands on a declining pool of trained S&T personnel, could result in diminished numbers of EC residents who come to the U.S. for long-term study and work. Concurrently, growing EC ties with EFTA and East European countries in S&T relations could result in greater EC focus on S&T education and training as a form of cooperation with those countries. Absent any stimulus to increase the numbers of American graduate students and younger professional S&T personnel who study and work in Europe, or to augment European study and training in the U.S., there may be a serious decline in the levels of U.S.-European interaction and cross-familiarity in research.

Issue: Does adequate support exist on the part of the U.S. government, academia and industry, for U.S. students and S&T professionals for long-term visits to Western Europe? Should the U.S. government provide greater flexibility and support for foreigners to visit the U.S. for education and professional work in S&T fields?

Assessment: Potential Consequences for U.S.-European S&T Cooperation of a Declining Level of S&T Personnel Exchanges

The problem of an inadequate pool of potential science and engineering talent in Europe is at least as severe as in the U.S. The available pool from which science and engineering (S&E) students would be drawn over the next decade is shrinking rapidly in every EC country, with only the UK showing potential for a slight reversal of the trend early in the next century. The problem is particularly acute in West Germany, which currently supplies 35% of the Community's S&E professionals and which is expected to experience a 45% decline in S&E students over the next decade. [Unification will not help the trend, as the demographic decline in eastern Germany is even sharper than in the western portion.]

In the United Kingdom, where university-age population decline is not so severe as in other EC countries, nevertheless the numbers of high school graduates, university students taking degrees in S&T fields, and S&T graduates pursuing professional careers are all so low as to cause critical alarm. As one example, the demand for courses in chemical engineering in 1988-89 fell 8.7% at traditional universities and 16.1% at polytechnic universities over the previous year; the corresponding figures for electrical engineering showed a drop of 11.9% and 7.4% respectively.

There is a rapidly aging professional science and engineering population throughout the EC, with approximately a quarter of currently active researchers reaching retirement age by 1995. In France, for instance, the median age of professional researchers in 1999 has been projected as forty-seven. A recent official report predicts that for two years alone, 2001-2002, demand for professors and lecturers in the sciences will outstrip the supply by 2,500 positions. Between 2000 and 2015, it is estimated that 70% of French faculty in science and engineering will retire.

To counter these trends, a variety of programs to attract students to S&T careers, and to motivate post-docs and young professionals to remain in Europe, are at the top of Community priorities, for both the Commission and the Member States individually. Efforts by the EC, in pilot mobility and exchange programs like COMETT and ERASMUS, are being designed and implemented to remove barriers to and coalesce national efforts in pursuit of this goal. Any notable success here will certainly be reflected in some reduction of European students who s' dy, and scientists and engineers who teach and work, in the United States.

Complicating the situation is the rapid growth, in both the U.S. and the EC, in recruitment of academic and public sector researchers to perform research for the private sector, with the resulting diminishment in the ratio of researchers to projects taking place in the open environment of fundamental research. At the same time, the flow of information pertaining to ongoing research and results is becoming somewhat restricted in those fields with identifiable commercial potential (microelectronics, biotechnology, advanced materials, chemical engineering, etc.). This has noticeably discernible effects on U.S.-EC cooperation at the level of such programs as JESSI and SEMATECH; it is also exerting less obvious effects on discussions about *future* fields of U.S.-EC cooperation where commercial benefits may emerge.

A resulting diminution in the levels and frequency of international contacts would exacerbate the problem of familiarizing American researchers and S&E students with European S&T activity and traditions. An exception may develop with U.S. professionals and students recruited to work in Europe. However, the numbers of U.S. expatriates are likely to be quite small, as the majority of U.S. S&T students and young professionals—like their counterparts in other fields—have relatively little professional experience of or ties to Europe.

U.S. Access to European Research Programs and Results

Concern: Increased emphasis in the EC on applied technologies research for international competitiveness, combined with the restrictions on non-EC participation in multinational R&D programs, may have a deleterious effect on U.S. access to European research projects and their results. The present uncertainty over the locus of authority in the EC for IPR issues, along with the absense of U.S. agreement with individual member states on IPR protections, further hinders US-EC cooperation.

Issues: In what ways should, and can, the U.S. government intervene on behalf of the U.S. research community to secure equivalent access to publicly-funded research in Europe? Given the relationship of intellectual property rights (IPR) to access, what is the nature of NSF interests in IPR discussions with the Europeans? Should IPR negotiations be conducted primarily through the EC or directly with each member state government? How can the U.S. and the EC work to create the widest possible access to information on research projects and results consistent with the objective of openness in public research funding?

Assessment: Present Situation Regarding U.S. Access to EC Research and the Role of Intellectual Property Rights

Access to participation in ongoing publicly-funded research, as well as to research results, is an area of concern. Despite repeated assurances from European officials, the organization and participatory criteria of several of the largest multilateral European research programs have created doubts about the transparency and openness of future S&T activities receiving EC support.

This concern has been particularly visible in the field of microelectronics R&D, where the bulk of both EC and EUREKA funding have been concentrated. Conditions for participation by U.S. subsidiaries in Europe that meet the "integrated presence" requirement seem to have eased recently with the IBM-Siemens joint research agreement, a virtual entree for IBM into the JESSI program. However, relatively few American firms can afford, or wish to divert, substantial fixed R&D resources and investment to Europe. The great majority of U.S. R&D-performing companies seem destined to be excluded from access to publicly-supported European research and technology development at the level of principal contractors. If the EC succeeds in opening up national procurement policies and markets on the basis of equality of access for *EC-based firms*, American high-tech small and medium enterprises (SMEs)—who currently receive

significant numbers of non-competitive sub-contracts through national procurements— ironically could be denied access to a greater extent than at present.

Another aspect of access involves intellectual property rights (IPR). Ownership of research results and rights to license such results has become a critical stumbling block in U.S. discussions with other nations on matters of trade, technology transfer and basic research. The EC is attempting to construct a common Community IPR policy and an instrument of application. However, it has encountered substantial difficulties both in obtaining consensus within the Community on specifics of a policy and in formulating compromise language close enough to the U.S. position to be negotiable. The informal agreement of EC member states to avoid "external" IPR commitments which might jeopardize formulation of a collective EC policy, however, may result in the absence of a common legal framework on IPR between the U.S. and any Community country individually. Such a situation would hinder most forms of basic and applied research collaboration.

The situation on the U.S. side changed considerably in mid-1990, with the adoption of a revised U.S. IPR policy. It incorporates language that provides increased flexibility and forms the basis for a new round of negotiations with individual EC countries. The revised policy addresses the more important concerns voiced in recent years by European government officials. More importantly, it satisfies U.S. concerns, mostly related to inadequate IPR protection in developing countries, by permitting U.S. agencies to tailor the language of agreements to meet their particular needs.

At a practical level for an American individual researcher, the access issue is not yet a problem. Individual U.S. researchers and entities can be (and are) hired or invited to participate in research projects receiving EC (or EUREKA) funding without discrimination, although rights to their findings belong to the inviting or hiring entity. By far, most U.S. participation involves research at university or public research facilities receiving support directly from the national governments, and access and IPR provisions are set by the particular country where the research is being performed. Little evidence of change has appeared at this level; however, the role of the EC research programs in creating or changing precedents should not be downplayed. Nor should the possibility be dismissed of a collective EC-wide IPR policy, administered by the Commission in dealing with non-EC states.

Collection, Assessment and Dissemination of European S&T Information

Concern: The U.S. capability to acquire, assess and disseminate information about European science and technology policies, resources, organization and capabilities suffers from inadequate resources and insufficient priorities.

Issue: What should be done by the U.S. government to increase the quantity and quality of information and assessments (I&A) on European science and technology? Are NSF efforts sufficient to provide timely and adequate information about European S&T to policy makers and public users?

Assessment A Need for Increased Resources

Regarding the ability of U.S. government agencies to collect, evaluate and disseminate information concerning European S&T, it may be insufficient to the task of informing and guiding a wide circle of potential users in the United States. Executive Order 12591 directed the Departments of State and Commerce, as well as NSF, in 1986 to develop such a capability; however, resources available and priorities attached to the task do not appear to be keeping pace with the growing need for information and analysis, especially regarding the European Community's rapid evolution.

For example, NSF has a staff of five assigned to foreign S&T information collection, analysis and dissemination, of whom two are temporary detailees. This staff began publishing a quarterly journal, *International S&T INSIGHT*, in late 1988. It has also constructed an on-line electronic database on foreign S&T, recently made available to public users, that must be supplied regularly with significant amounts of new information and culled of out-of-date material. It is also a principal source of policy-support activity for NSF's international cooperative programs and initiatives. Only two of the staff are responsible for covering Europe. NSF's Europe Office, in Paris, is staffed by one professional.

As another example, the State Department has developed the STRIDE system for disseminating cable traffic on substantive European S&T developments from U.S. embassies overseas. Despite noteworthy efforts by the agency to raise the profile and priority of S&T reporting and distribution, the system still suffers from a

paucity of both information and channels for dissemination outside the State Department. Moreover, the reporting format does not lend itself to easy reading by those not familiar with State Department cable traffic.

Other agencies conducting S&T activities with European counterparts tend to concentrate understandably on the relatively narrow operational aspects of their particular mission objectives, where resources are applied in an *ad hoc* manner to acquiring and assessing information as the need arises. Seldom is such information or assessment put into written form, particularly any form available to a public audience.

Standards-Setting and Regulatory Processes

Concern: Potential advantages to U.S. advanced technology research and competitiveness deriving from the Single Market could be hindered or obstructed by the EC's use of standards-setting and regulatory processes to discriminate against non-EC products. The standards setting process is open at the initial technical level only to participants from EC and EFTA countries, and the U.S. lacks access to EC regulatory processes. A unified EC system may further hinder U.S. access to the Single Market, via scientific discovery and techno-logical innovation, through the adoption of non-scientific considerations in establishing standards and regulatory regimes, especially in emerging fields with clear applications potential.

Issues: How can the U.S. government most effectively work to ensure that EC standards and regulations are based upon sound scientific criteria and that non-scientific economic or political factors are not included as criteria? What approach should be undertaken to obtain greater openness, or transparency, in the European standards-setting and regulatory processes, especially as they apply to research activities?

Assessment: Influences of European Standards and Regulatory Processes on U.S. R&D and Advanced Technology Competitiveness

This topic affects principally U.S. industrial applied R&D. However the potential for U.S. exclusion from European *pre-normative* standards processes, as well as from the regulatory environment, carries implications for some fields of basic research as well. The emergence of EC-wide standardization and regulation of advanced technology goods and services potentially can provide tremendous advantages for U.S. firms in R&D, as well as marketing. However, potential exists to delay, inhibit or otherwise obstruct competition from non-EC goods and services. This in turn might adversely affect the U.S. R&D and marketing activities necessary to compete effectively in quality and innovation.

U.S. entities and individuals are denied official access to European deliberations at those early points in the processes that establish parameters for technology applications and product technical, health and safety standards. The U.S. telecommunications industry for example has complained that, in European deliberations pertaining to ISDN and OSI technologies, European companies have the advantage of foreknowledge of future standards through their participation in CEN/CENELEC deliberations, which are closed at the technical level even to observation by private sector representatives from non-European countries.

Additionally, major European public R&D investment choices can themselves strongly influence, if not determine, decisions on future standards in given fields, with negative impact on those who choose to invest in competing or different R&D activities. And not least, regulations can be implemented to satisfy public apprehensions concerning product and process safety and control, despite the absence of solid technical or scientific foundation for those perceptions - the so-called "fourth criterion.". The current vociferous debate in Europe—and concomitant variations in the regulation of research—over the scientific basis for EC-wide regulations on testing and release of biotechnologically-produced or genetically-engineered organisms are illustrative of the vulnerability of R&D programs to the politicization of standards and regulatory processes.

Civilian Research and Technology Assistance to Eastern Europe

Concern: East European economies lack both the market-based S&T infrastructure and the entrepreneurial, capitalist-oriented R&D management cadre necessary to attract and utilize Western technological assistance, particularly that available from the private sector. A related concern is that the East European transition to a market economy, and

the related deepening of democratic political processes, may be hindered by difficulties in obtaining Western, particularly U.S., technologies and R&D management expertise.

Issues: Should U.S. policy, affecting non-militarily critical technology and know-how, promote the transfer of needed scientific and technical knowledge, training, skills and products to Eastern Europe?

Assessment: S&T Assistance to Eastern Europe: Opportunity for US-EC Cooperation

In the aftermath of the 1989 revolutions in Eastern Europe, the organization and structures in those countries for performing and promoting research and technology development have been revealed as completely inadequate and poorly designed for attracting and utilizing the S&T assistance potentially available from the West. Advanced technologies are needed to jump-start worn-out, collapsing economies and provide the underpinnings for democratic liberalization. Applied technology development capabilities are particularly needed, and quickly, to underwrite the transition from crumbling, anachronistic manufacturing and service industries. Assistance is also critical to the reformation of research. Criteria for both research and engineering personnel, formerly based largely upon political and ideological acceptability, must be changed to reflect emphasis on quality and competitiveness.

Western financial assistance and technical know-how is available in limited degree from the Group of 24 governments, administered through the EC's PHARE program. Much greater resources are potentially available from private sector corporate and banking investment capital. However, the utilization of the former, and the attraction for the latter, depend heavily on the success of efforts to restructure East European science and technology from a top-down, command system to one in which ideas, proposals and funding are responsive to quality and need, as determined by the R&D community and the larger marketplace.

The EC is currently renegotiating trade and cooperation agreements with Hungary, Czechoslovakia, Poland and Bulgaria, all of which will specifically include S&T cooperation. Events generally seem to indicate that, in the not-too-distant future, Poland, Czechoslovakia, and Hungary may be interacting with the EC very closely in economic and S&T matters, much in the way of the current relationship between the EC and the European Free Trade Association countries. The EC Commission has identified the transfer of technology to Eastern Europe as a priority, and much of the time and attention of the two principle research directorates-general are devoted to identifying opportunties and drafting plans for such assistance. S&T Commissioner Filipo Pandolfi has suggested that the U.S. and the EC might jointly develop a policy and programs for effective S&T aid to Eastern Europe, a proposal under consideration by the President's Science Advisor, Dr. Allan Bromley.

Many U.S. companies are considering investments in these countries, but antiquated, collapsing or absent infrastructures there, along with a relative paucity of R&D management experienced in Western business practice and market philosophy, have made all but the largest corporations wary of making sizeable or longterm commitments. A major bottleneck is the lack of well-trained S&T personnel, especially in R&D management, who are familiar with the close industry-academic-government pattern of cooperation in the West.

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