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S&T Collaboration

Ideas for Enhancing European-American Cooperation

About the President's Council of Advisors on Science and Technology

President Bush established the President's Council of Advisors on Science and Technology (PCAST) by Executive Order 13226 in September 2001. Under this Executive Order, PCAST "shall advise the President ... on matters involving science and technology policy," and "shall assist the National Science and Technology Council (NSTC) in securing private sector involvement in its activities." The NSTC is a cabinet-level council that coordinates interagency research and development activities and science and technology policy making processes across federal departments and agencies.

PCAST enables the President to receive advice from the private sector, including the academic community, on important issues relative to technology, scientific research, math and science education, and other topics of national concern. The PCAST-NSTC link provides a mechanism to enable the public-private exchange of ideas that inform the federal science and technology policy making processes.

PCAST follows a tradition of Presidential advisory panels on science and technology dating back to Presidents Eisenhower and Truman. The Council's 23 members, appointed by the President, are drawn from industry, education, and research institutions, and other nongovernmental organizations. In addition, the Director of the Office of Science and Technology Policy serves as PCAST's Co-Chair.

Acknowledgements

PCAST would like to thank the members of EURAB who traveled to Washington to participate in this workshop. PCAST would also like to thank Mary Kavanaugh and Alessandro Damiani, both of the Delegation of the European Commission to the United States of America, who played a special role in assisting PCAST in organizing the workshop.

S&T Collaboration

Ideas for Enhancing European-American Cooperation

Summary of a Workshop convened by the
President's Council of Advisors on Science and Technology

October 5, 2004
Washington, DC

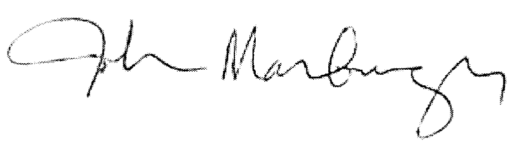
Preface

Science has always spanned the boundaries of nations, languages, and cultures—advancing by the cooperation and competition among those seeking new knowledge and technology. Today more than ever, scientific research is a global pursuit that benefits from multi-national collaborations and liaisons among researchers and institutions.

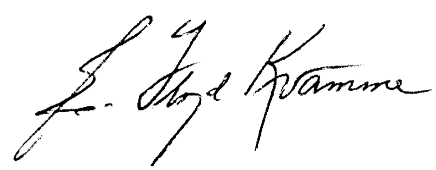
The President's Council of Advisors on Science and Technology (PCAST) has studied various aspects of the innovation process, and views the U.S. Federal research enterprise as one of many inter-related elements. A vital connection in the innovation ecosystem is that between the United States and the members of the European Union (EU). In light of rapidly increasing globalization of the world's economy as well as ongoing partnerships on a number of large scientific projects, PCAST felt it was timely to look at the status of the science and technology (S&T) linkages between the United States and Europe.

On October 5, 2004, PCAST convened a workshop in Washington, D.C. on *S&T Collaboration: Ideas for Enhancing European-American Cooperation*. Several members of the European Union Research Advisory Board also participated. Discussions ranged among diverse topics, including support for and access to large facilities, jointly defined research priorities, and educational opportunities and researcher mobility between the United States and European nations.

The workshop confirmed that the United States and the EU share many of the same concerns when it comes to sustaining and creating innovation, economic strength, job opportunities, and technological leadership. Moreover, the workshop participants noted that global challenges—access to clean energy, potable water, and affordable healthcare—that can benefit from advances in science and technology, call for cooperative and coordinated efforts among the United State, European Union, and others. Interactions at all levels will be needed to achieve these goals, and PCAST members are hopeful that workshops such as this will encourage such activities.



John H. Marburger, III
Co-Chair



E. Floyd Kvamme
Co-Chair

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Mechanical Engineering,
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European Research Advisory Board Members

PCAST is pleased that the following members of the European Research Advisory Board (EURAB) joined PCAST for this workshop:

Jean-Luc Bredas
Professor of Chemistry,
School of Chemistry & Biochemistry
Georgia Institute of Technology (Belgium)

Kari-Pekka Estola
Vice President Nokia Research Centre (Finland)

Ian Halliday
Chief Executive of the Particle Physics & Astronomy Research Council (United Kingdom)

Jens Rostrup-Nielsen
Director of Research & Development Division,
Member of Executive Board,
Haldor Topsoe A/S (Denmark)

Horst Soboll
Director, Research Policy,
DaimlerChrysler AG (Finland)

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Executive Summary

In October 2004, the President's Council of Advisors on Science and Technology (PCAST) convened a one-day conference to permit representatives from the United States and the European Union to explore current issues related to transatlantic scientific cooperation among individuals, research institutions, corporations, and nations.

The workshop was organized into four panels:

- Enhancing International Mobility for European and American Researchers
- Funding Collaborative Research
- Negotiating Differences in Legal and Regulatory Approaches
- The Future of Transatlantic Science Collaborations – Success Stories and Trends

The panelists, representing academia, government, and business, were asked to focus on questions such as:

- What are the barriers to European-American cooperation?
- What are potential ways to remove barriers to European-American cooperation?
- What successful mechanisms and strategies have allowed European-American cooperation to be robust to-date?

As a result of the lively discussion about these and other related topics, several areas of opportunity emerged that can be grouped into four functional categories:

Facilitating Mobility and Career Development

- Progress still needed on the issue of visas.
- Metrics with regard to visa issuances, processing, and delays and the broader dissemination of this information.
- International educational opportunities, especially at the undergraduate level, as a mechanism to foster research collaboration in an era of global science and technology.

Maintaining and Encouraging Access to International Facilities

- Research areas or objectives that may be particularly suited for collaborations based around large-scale facilities.
- Economic and scientific outcomes and impacts of existing international centers and facilities projects.
- Best practices from facilities such as Deutsche Electronen-Synchrotron (DESY) and Counseil Européen pour le Recherche Nucleaire (CERN), the European Organization for Nuclear Research, and agencies such as the U.S. Department of Energy and NASA, to understand effective organizational and managerial strategies for future facilities.

Navigating Organizational and Regulatory Issues

- Organizational changes within the European Union that will facilitate collaboration.
- Best practices that may support the development of future trans-Atlantic initiatives.
- Legal and regulatory issues that may affect efficient and timely collaboration.

Supporting National and International Research Priority Areas

- Mechanisms that have allowed international initiatives, such as the International Partnership for the Hydrogen Economy and FreedomCAR to be successful.
- Potential to coordinate future planning documents between the United States and European Union to help identify areas for collaboration.
- Benefits and drawbacks to communicating long-term plans through roadmaps.

From space exploration and high energy physics, to ground-based telescopes and biotechnology, cooperative efforts between the United States and the European Union have led to scientific breakthroughs, economic benefits, and perhaps most importantly, strong friendships at many levels with important implications for global prosperity.

PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY
S&T Collaboration: Ideas for Enhancing European-American Cooperation

Ronald Reagan Building & International Trade Center
Washington, DC 20004

October 5, 2004

AGENDA

Welcome and Introductions
8:30 – 8:40 a.m.

The Honorable E. Floyd Kvamme, PCAST Co-Chair
Partner, Kleiner Perkins Caufield & Byers

The Honorable John H. Marburger, III, PCAST Co-Chair
Director, Office of Science and Technology Policy, Executive Office of the President

Opening Remarks
8:40 – 9:00 a.m.

The Honorable Spencer Abraham
Secretary, Department of Energy

Panel 1 - Enhancing International Mobility for European and American Researchers
9:00 – 10:30 a.m.

The free movement of researchers between the United States and Europe is a critical dimension of contemporary science and technology. Panelists will discuss current issues—including visas, the internationalization of the S&T workforce, and new and needed mechanisms to promote international mobility.

Shana Dale, Moderator
Chief of Staff and General Counsel, Office of Science and Technology Policy, Executive Office of the President

The Honorable C. Stewart Verdery, **Jr.** Panelist
Assistant Secretary for Border and Transportation Security Policy and Planning, U.S. Department of Homeland Security

Janice Jacobs, Panelist
Deputy Assistant Secretary of State for Visa Services, Bureau of Consular Affairs, U.S. Dept. of State

Richard C. Powell, Panelist
Vice President for Research and Graduate Studies, University of Arizona

Bruno Schmitz, Panelist
Head of Research Training Networks Unit, Research Directorate-General, European Commission

Discussion with Panel: PCAST and European Research Advisory Board (EURAB) Members

Break
10:30 – 10:45 a.m.

Panel 2 - Funding Collaborative Research
10:45 a.m. – 12:15 p.m.

A number of funding mechanisms are available to support international collaborative research. In one scenario, participating partners pay for their share of the work; in another, researchers from one country may work for sponsoring research organizations in another country. Funding mechanisms have also emerged on either side of the Atlantic designed to facilitate independent collaborative research. Panelists will discuss strategies for facilitating European-American collaborative research in the future.

The Honorable Arden Bement, Moderator
Director (Acting), U.S. National Science Foundation

Alphonso Diaz, Panelist
Associate Administrator for Science, U.S. National Aeronautics and Space Administration

Pablo Fernandez Ruiz, Panelist
Director, Energy Directorate, Research Directorate-General, European Commission

William J. Willis, Panelist
Columbia University and Project Manager, U.S. ATLAS Program at CERN

Discussion with Panel: PCAST and EURAB Members

Lunch Break
12:15 – 1:30 p.m.

Panel 3 - Negotiating Differences in Legal and Regulatory Approaches
1:30 a.m. – 3:00 p.m.

A variety of regulatory/legal/policy issues exist which cause United States and European scientists approach their research from quite different traditions. Such differences can spillover into the development of trans-Atlantic research collaborations. Panelists will discuss these matters—such as intellectual property rules, standards development, and trade policies—with a focus on how they impact successful collaborations.

The Honorable Phillip J. Bond, Moderator
Under Secretary for Technology, U.S. Department of Commerce

Michael Maibach, Panelist
President and CEO, European-American Business Council

Andrew Dearing, Panelist
Secretary General, European Industrial Research Management Association

Martin Mullins, Panelist
Vice President for Technology Licensing, Georgetown University

Discussion with Panel: PCAST and EURAB Members

Break
3:00 – 3:15 p.m.

Panel 4 - The Future of Trans-Atlantic Science Collaborations-Success Stories and Trends
3:15 – 4:45 p.m.

Despite the challenges that exist in current efforts to promote European-American collaboration in science and technology, substantial successful collaboration is in place. Moreover, current trends and ongoing initiatives may require or allow even more robust collaboration in the future. Panelists will describe their experiences in promoting collaborations between the United States and Europe, lessons learned, and future challenges.

The Honorable Kathie L. Olsen, Moderator
Associate Director for Science, Office of Science & Technology Policy,
Executive Office of the President

James DeCorpo, Panelist
Technical Director, U.S. Office of Naval Research, Global, London

Pablo Fernandez Ruiz, Panelist
Director, Energy Directorate, Research Directorate-General, European Commission

Albrecht Wagner, Panelist
Chairman of the Board of Directors, Deutsche Elektronen-Synchrotron (DESY)

The Honorable Conrad C. Lautenbacher, Jr., Panelist
Administrator, U.S. National Oceanographic and Atmospheric Administration

Discussion with Panel: PCAST and EURAB Members

Concluding Remarks and Discussion
4:45 - 5:30 p.m.

Adjournment

Introduction

The United States and Europe have a long history of scientific cooperation at the national, corporate, institutional and individual levels. From the Orbiting Solar Observatory missions in the 1960s to the current United States-European Commission Task Force on Biotechnology, these collaborations have spanned and enabled political, economic, social, and technological change. In 2000, European-owned companies invested $18.6 billion on research and development in the United States, whereas U.S. companies invested $12.9 billion in Europe (NSB 2004, U.S. and international research and development: Funds and technology linkages).[1] Changing patterns of U.S. and European co-authorship are another indicator of the strength of transatlantic, scientific cooperation (NSB 2004, Appendix 5.44).

The European Union (EU) and United States have various mechanisms to facilitate scientific cooperation. These mechanisms—bilateral research opportunities for students, shared access to research facilities, and focused support for international research and development priority areas—are critical components of scientific progress. Cooperation allows countries to draw upon the talents of international researchers, share access to research results, and keep abreast of technologies that may be of scientific, civilian, military, political and economic importance. As the cost of supporting science, especially large-scale projects and facilities (e.g., the Large Hadron Collider at CERN, the Hubble Telescope, and the International Space Station), continues to grow, there is the continued need to discuss these mechanisms, as well as research priorities to sustain robust, transatlantic, scientific cooperation.

In October 2004, the President's Council of Advisors on Science and Technology (PCAST) convened a one-day conference to permit representatives from the United States and the European Union to explore current issues related to transatlantic scientific cooperation at the individual, academic, corporate, and national levels.

The conference, the first of its kind devoted exclusively to international issues, was held at a critical time. Within the United States, Federal Government agencies such as the Department of Energy (DOE) and the National Institutes of Health (NIH) are developing roadmap initiatives that will both determine and drive the agencies' long-term scientific research and development (R&D) goals. Within the EU, the Seventh Framework Programme—the five-year research funding mechanism used by member countries—is scheduled to take effect in 2007; it will likely expand the already robust international component of EU-sponsored research. Furthermore, the EU recently expanded its membership from 15 to 25 states, opening up new opportunities for research and cooperation both within the EU and with the United States. These events made the workshop particularly timely.

The workshop was organized into four panels:

- Enhancing International Mobility for European and American Researchers
- Funding Collaborative Research
- Negotiating Differences in Legal and Regulatory Approaches
- The Future of Transatlantic Science Collaborations—Success Stories and Trends

The panelists, representing academia, government, and business, were asked to focus on questions such as:

- What are the barriers to European-American cooperation?

[1] Please note that these numbers refer to all European countries, not just members of the European Union.

- What are potential ways to remove barriers to European-American cooperation?
- What successful mechanisms and strategies have allowed European-American cooperation to be robust to-date?

As a result of the lively discussion inspired by these and other topics, key issues emerged during the meeting that can be grouped into four functional categories. This report explores each of these categories in detail, so that future PCAST discussions on international cooperation in science and technology may be guided accordingly. The four categories are:

- **Facilitating mobility and career development:** With the increasing globalization of the workforce, the facilitation of international opportunities for research and employment is critical. Balance must be maintained between the availability of such opportunities and the need for security.
- **Maintaining and encouraging access to international facilities:** International facilities provide students and scientists with invaluable opportunities for collaboration, while reducing the costs to each nation of supporting scientific endeavors. Key to the future of transatlantic and global research is the development of shared facilities that are open to researchers from the EU, the United States, and other nations.
- **Navigating organizational and regulatory issues:** Countries seeking to maintain and improve transatlantic scientific research should understand the best practices for organizing cooperative efforts. They can likewise encourage future cooperation by creating a level playing field with regard to regulatory, legal, and policy issues. Such action will ensure fair participation in, and access to, research and its products.
- **National and international research priority areas:** Open dialogues are needed to determine areas of science and technology research that are of mutual interest among countries. Roadmap initiatives in the United States and Framework Programmes in the European Union may allow scientists, institutions, and governing bodies to identify transatlantic issues that are best pursued through joint efforts.

Facilitating Mobility and Career Development

The United States and the European Union are part of a knowledge-based global economy. With the increasing globalization of the science and technology workforce, promotion of international opportunities for scientific study, research and employment have never been more important. Workshop presenters highlighted two specific benefits, namely:

"Advances in science and technology depend upon global cooperation, mobility, and exchange. At a strategic level, we must continue to build strong bridges between those whose mandate it is to protect us, and those whose mandate it is to seek scientific progress."

- Shana Dale

- Individuals who study in a foreign country and then return home again familiarity with the values and customs of the host country, and obtain experience working with others from different backgrounds and cultures.
- Foreign scientists contribute to economic prosperity by filling jobs that would otherwise not be filled. For example, the United States depends on foreigners to fill important jobs in electrical engineering, because there are not enough U.S.-born scientists interested in studying and working in this field.

"International experiences give our students the ability to succeed in a global economy, and they can enhance the image of the U.S. throughout the world."

- Richard Powell

Dr. Richard Powell, Vice President for Research Graduate Studies and Economic Development at the University of Arizona, was one of many workshop participants who noted specific examples of successful ongoing programs that serve these functions. Dr. Powell cited the following programs: QuarkNet for high school students; the Biomedical Research Abroad Vistas Open (BRAVO) program, sponsored by Howard Hughes Medical Institute and the National Institutes of Health, for undergraduates; and the Peace Fellowship Program, part of the International Arid Lands Consortium, for graduate students. In addition to providing unique opportunities for research and cultural exchange, such initiatives establish mentoring relationships that can change people's careers.

"We believe that the scientific community is one of our best weapons in the war against terrorism. It's the ideas that will be generated by the brightest minds in the world that will help us combat the terrorists."

- C. Stewart Verdery

Although the United States and the EU must endeavor to maintain these unique opportunities and to promote mobility, the terrorist attacks of September 11, 2001 profoundly changed security concerns and policies throughout the world. These changes have had significant impact on the mobility of international students and scientists. In the past three years, all nations have had time to evaluate strategies and assess concerns, and the goal now is to find a balance between international science and international security.

Some workshop participants expressed concern that the use of the Student and Exchange Visitor Information System (SEVIS) may prevent students from coming to the United States. Others noted that the use of International Traffic in Arms Regulations (ITAR) may prevent the flow of materials and information necessary to conduct research. However, the most heavily discussed issue related to the effect of security on openness was in regard to the issuance of visas, particularly in the United States.[2] A number of presenters and workshop participants noted instances in which individuals from EU member states were subjected to repeated security checks, experienced delays in visa issuances, and even jailed overnight while being investigated. Panelists C. Stewart Verdery, from the Department of Homeland Security's Border and Transportation Security Directorate, and Janice Jacobs, Deputy Assistant Secretary for Visa Services, Bureau of Consular Affairs at the State Department, each described what is being done to prevent unnecessary delays, improve screening processes, and maintain a balance between "secure borders and open doors."

[2] This issue is discussed in more detail in Appendix C.

Mr. Verdery noted that especially since September 11, 2001, the United States has forged strong relationships and partnerships with members of the European Union in key areas. For example, formal mechanisms have been established to exchange airline passenger data as well as information about visa policies, cargo security, and biometrics. Metrics are also being developed to track and report the effectiveness of security mechanisms. For example, in January 2004 the Department of Homeland Security launched US-VISIT, a program that uses biometrics for identity verification purposes. It allows an individual's picture and fingerprints to be verified against a database in approximately six seconds. In the first nine months of the US-VISIT program, nine million individuals were processed at ports of entry, resulting in 1,200 "hits" and approximately 400 cases where an individual was denied entry or arrested. In addition to the US-VISIT program, Mr. Verdery stressed the recent efforts of the Department of Homeland Security and all frontline security personnel to act professionally and to treat individuals going through screening processes with dignity and respect.

"One of the foundations of the U.S. scientific community, of course, is to have in place a vibrant international community of foreign students here in the United States."
- Janice Jacobs

According to Ms. Jacobs, currently about 97 percent of eligible individuals who apply for a visa receive one within two days of their interview, while only about two percent undergo lengthier review by a security advisory board. Furthermore, in 2003 the average processing time for Visa Mantis cases was 60 days, while by September 2004, 98 percent of Visa Mantis cases were handled in fewer than 30 days.[3] This improvement is due in part to the priority that all visa processing posts now give to students, research scholars, and exchange visitors when setting appointments, and in part to the addition of 350 new consular positions since September 2001. Ms. Jacobs also emphasized that by posting visa requirements online, the State Department has attempted to make the visa process more transparent to foreign citizens.

Ms. Jacobs noted that the number of visa applications and issuances are not as high as they were before September 11, 2001, but she stressed that the numbers are rising. Specifically, from January to June of 2004, total visa applications increased 10.4 percent, total issuances increased 13.6 percent, and student visa issuances increased 11.2 percent, compared to the same time period in 2003. Although these increases are encouraging, Mr. Verdery and Ms. Jacobs explained that their organizations will continue to work with the academic and business communities to further improve policies and procedures to enable even greater increases in the future.

"As the world shrinks and it is shrinking more all the time, especially with information technology it is important that those researchers have an international experience as part of their research opportunity."
– Charles Arntzen

From the European perspective, Mr. Bruno Schmitz, Head of the Research Training Networks Unit in the Research General Directorate of the European Commission, emphasized the importance to the EU of mobility and the measures it has taken to encourage it. In March 2002, the Barcelona European Council set an objective to increase the average investment in research and development in Europe from 1.9 percent of the gross domestic product (GDP) in 2002 to 3 percent of GDP by 2010, two-thirds of which should be funded by the private sector. To achieve this goal, an estimated 600,000 to 700,000 new researchers will be needed in Europe during the next 10 years. As a result, researcher mobility, training, and career development are considered priorities by all EU member states.

[3] Visa Mantis cases are those where an individual has applied for a visa, and the U.S. government determines that the individual's case requires further review because of U.S. laws that prohibit the issuance of a visa to someone who may violate prohibitions on the export of goods, technology and sensitive information from the United States. Because of the nature of their work, scientists and engineers are particularly subject to these Mantis cases.

The EU Researchers Mobility Portal, which allows European institutions to advertise research posts worldwide, is one example of an existing mechanism for enabling mobility. The Portal has been implemented with the cooperation of many American partners, including Science Magazine's Next Wave program. The European Union has also established the European Network of Mobility Centers, which consists of centers throughout Europe that enable international researchers to become acclimated to foreign countries and to establish contacts.

Mr. Schmitz also noted that all activities of the Sixth Framework Programme are open to third-country participation in order to bring in the best researchers from around the world and engage them in important research. The EU's large portfolio of activities and mechanisms is meant to stress that the EU-U.S. scientific cooperation is important and that supporting and expanding it is a priority for the EU.

Several European Research Advisory Board (EURAB) and PCAST representatives at the workshop, as well as panelists, stressed that despite the specific barriers discussed at the workshop, the United States and Europe have a strong collaborative relationship, and that the barriers are being overcome. Dr. James DeCorpo, Technical Director, U.S. Office of Naval Research (ONR) Global, London, noted that ONR sends approximately 200 scientists to the United States annually to visit colleagues and to develop collaborative efforts. Dr. Arden Bement, then-Acting Director of the National Science Foundation, noted the variety of exchange mechanisms supported by the National Science Foundation, including undergraduate research abroad; dissertation awards; global scale partnerships; single investigator and multi-investigator collaborations; and shared opportunities at large facilities.

Areas of Opportunity

- *Progress still needed on the issue of visas.*
- *Metrics with regard to visa issuances, processing, and delays and the broader dissemination of this information.*
- *International educational opportunities, especially at the undergraduate level, as a mechanism to foster research collaboration in an era of global science and technology.*

Maintaining & Encouraging Access to International Facilities

Access to international scientific facilities is a critical part of EU-U.S. cooperation. Such facilities provide students and companies with opportunities to conduct international research; create local jobs; reduce the costs of research for involved parties; and minimize duplications of effort.

There are many examples of international facilities that have been supported through EU-U.S. cooperation. Dr. Arden Bement cited, for example, the Gemini Observatory and the ATLAS Experiment at the Large Hadron Collider. Dr. William Willis, Program Manager of the U.S. ATLAS Program at CERN, and Dr. Albrecht Wagner, Chairman of the Board of Directors of Deutsche Elektronen-Synchrotron (DESY) described the many ways that these facilities have successfully fostered international cooperation for decades.

Workshop panelists and participants explained several principles that have been used successfully to guide the formation of large-scale infrastructure partnerships. Dr. Bement highlighted the principles that NSF has used, including: a fundamental commitment to peer-reviewed, high quality interactions of mutual benefit; the integration of research and education; the willingness to understand partners' processes and approaches; the provision of open and reciprocal access to all researchers; and the sharing of discoveries and developments from joint investments. Dr. Bement also highlighted the importance of considering cost models, governance, accountability, and evaluations when participating in large international infrastructure partnerships. Each infrastructure project must be developed through iterative dialogues and long-term planning with all stakeholders in the research community.

> *"Would I be happy if everything over the next 20 to 30 years was built outside of the United States? Absolutely not. Would I want to see us feel good about spending U.S. tax dollars on unique facilities located in Europe that we were all going to share? Absolutely. So, it is a balancing act."*
> - Charles Vest

PCAST and EURAB members noted a number of concerns related to the construction of facilities, namely the difficulty of getting the United States Congress to commit to the long-term funding of facility construction, and disagreements over facility locations such as the International Thermonuclear Experimental Reactor (ITER). Several workshop participants remarked that, given its resources, the United States should take a strong leadership role in identifying and constructing scientific facilities. Furthermore, participants urged, large scientific facilities should be distributed around the world and be accessible to all scientists.

Seeking ways to pull down or work around such barriers, workshop participants pointed to a number of existing avenues that can be used to create future collaborations. First, as noted by participants from both the EU and the United States, robust informal and formal transatlantic cooperation already exists around facilities such as CERN, Deutsche Forschungsgemeinschaft (DFG), and DESY. Second, as outlined by Energy Secretary Mr. Spencer Abraham and others, long-term priorities and roadmaps are being developed with an eye toward transatlantic and international collaboration.[4] Two notable examples of high-priority, long-term facilities are:

[4] For more information on the development of roadmap documents and on the identification of international priority areas, please see section on Supporting National and International Research Priority Areas.

- ITER, which will explore the possibilities of fusion technology to generate power at the level of an electricity-producing power station.
- FutureGen, the initiative to build the world's first integrated sequestration and hydrogen production research power plant.

The merits and implications of such international facilities and opportunities generated discussion about their potential and actual impacts on the local, transatlantic and global levels. PCAST members Dr. Charles Vest and Dr. Luis Proenza suggested that, as existing collaborative initiatives are developed and new ones are explored, all relevant parties examine the existing examples and data on the scientific and economic impact of similar international facilities. Dr. Proenza noted several examples of internationally distributed research centers that have had tremendous scientific and economic impacts, such as the International Maize and Wheat Improvement Center in Mexico and the International Crops Research Institute for the Semi-Arid Tropics, based in India. Mr. Steven Papermaster also noted that the Clean Coal Power Initiative, in which 14 countries participate, has created local jobs and supported research that will benefit the world.

"If we had a flow of all the brilliant researchers in one direction to one place then that would make you feel not so positive."
- C. Wayne Clough

Many PCAST members, including Mr. Floyd Kvamme and Dr. C. Wayne Clough, discussed the beneficial global infrastructure that will result from the creation of a network of international facilities. As an example, Dr. Clough noted the program underway, with the help of the NSF, to construct an information network that will allow offsite researchers at Georgia universities to use the research infrastructure at Oak Ridge National Laboratory. As another example, Dr. Marburger described the international use of x-ray synchrotrons located in the United States. With many unique facilities being developed under a variety of initiatives such as the Department of Energy's 20-year Facility Plan, the opportunities for researchers to run experiments remotely through world-class facilities and to optimize a global system of innovation networks are steadily increasing.

Areas of Opportunity

- *Research areas or objectives that may be particularly suited for collaborations based around large-scale facilities.*
- *Economic and scientific outcomes and impacts of existing international centers and facilities projects.*
- *Best practices from facilities such as DESY and CERN, and agencies such as DOE and the National Aeronautics and Space Administration (NASA), to understand effective organizational and managerial strategies for future facilities.*

Navigating Organizational and Regulatory Issues

Ideally, the organizational structure in which scientific research occurs—including research teams, institutions, governments, and the policies that support them—has no direct influence on research. In practice, however, administrative divisions within the organization can create artificial barriers to collaboration. Workshop participants discussed two sets of issues with regard to organizational and regulatory frameworks, each of which is discussed in detail below:

- Best mechanisms and practices for forming and sustaining international collaborations
- Regulatory, legal, and policy issues with regard to intellectual property, standards, and trade

"I think if we want to address the aspect of how do we do funding for collaborative research in Europe, we should understand that we have in the European Union and the U.S., two different systems."

- Pablo Fernandez Ruiz

Best mechanisms and practices for forming and sustaining international collaborations

Presenters highlighted several models currently being used to support scientific collaborations between the EU and United States Mr. Alphonso Diaz, NASA Associate Administrator for Science, explained that his agency supports proposals for investigator-initiated (or "bottom-up") research that fits within the NASA mission. Such proposals often include international teams of researchers that either take the lead in developing and providing a specific technology or jointly manage the project. The case of the Cassini-Huygens mission to Saturn is an example of the former; the European Space Agency (ESA) provided the space probe. TOPEX/Poseidon, a cooperative mission between NASA and Centre National d'Etudes Spatiales, the French space agency, is an example of the latter. In all instances, international cooperation is funded to the extent that it falls within the existing NASA mission.

The Honorable Conrad C. Lautenbacher, Jr., Administrator, National Oceanographic and Atmospheric Administration, described the Global Earth Observation System of Systems (GEOSS) and the steps that were taken to create it. The system, which assists developing and emerging countries in achieving social and economic growth, stemmed from the 2003 Earth Observation Summit. 34 nations participated at the ministerial level in the Summit, which led to a declaration of the need for a system for encouraging the development of data sharing policies and the creation of an information management system. The plan is to integrate existing observation and data systems, then identify gaps and synergies that will drive the next steps in the project. The ultimate goal is to create a distributed system of systems that allows scientists and policy makers to better study and understand complex problems, such as the spread of malaria, global weather patterns, water cycles, and ways to provide clean drinking water. The collaboration resulted from an effort to identify the objectives, then creating the means to achieve them, largely through improving existing national systems.

"Whether it's a high cost facility or a common objective in energy in the future, it is much easier to get an agreement to the best funding mechanism than[to]have theoretical debates on funding mechanisms for programs[and]then coming with 10,000 different, diverse research projects."

- Horst Soboll

A third model, described by Dr. Wagner, incorporated both the "bottom-up" and "top-down" approach to creating collaborations in the field of particle physics. This community is organized under the International Committee for Future Accelerators, which was created in 1976 to promote international collaboration around particle accelerators and high energy physics. Under this committee, multiple roadmaps were developed by different geographic regions and similar priorities identified. As a result, existing projects in particle physics that were initiated at the individual-investigator level have been coupled to a strong institutional-level component that stems from the common roadmap visions. This has created a strong driving force between future initiatives of mutual interest, such as the International Linear Collider.

"Things are getting more and more expensive, and we need more and more partners, and more and more sharing of responsibility, which leads to less and less management efficiency.

- John Marburger

Mr. Pablo Fernandez Ruiz, Director of the Energy Directorate within the Research Directorate-General of the European Commission, explained the European Union's Framework Programme (FP), which the EU member nations use as a common tool to coordinate scientific research. The FP is divided into a host of thematic priorities, as well as projects and activities geared toward creating a European Research Area. Frameworks last for five years, with the fifth year of one program overlapping with the first year of the next. The Sixth Framework Programme (FP6) is currently in place; the Seventh Framework Programme (FP7) will commence in 2007.

The FP funding process encourages proposals that facilitate international participation where appropriate or necessary for accomplishing the project. Collaborative projects under the FP umbrella are open to third party participation.

"One word is the key to my experience, and that is responsibility."

- William Willis

In considering these and other similar organizational models that have successfully supported international collaboration, workshop participants also acknowledged and discussed concerns over certain organizational barriers to collaboration. Many of these barriers appear to be the result of the different structures, requirements, restrictions, and rules in place in the United States and the EU for sponsoring scientific research. Many participants noted collaboration can be easily improved simply by communicating more effectively about the structure of the respective systems. For example, Mr. Ruiz cited recent examples where U.S. companies and organizations misunderstood their eligibility to participate in EU activities.

Dr. Vest and EURAB Member Dr. Ian Halliday noted that researchers often have difficulties understanding the most appropriate level to coordinate research between the EU and United States—among researchers, institutions, agencies, or some combination of these stakeholders. Dr. Halliday stated that while in some cases the coordination is self-evident – for example, NASA would coordinate with ESA—in other cases the appropriate European counterpart is not yet formally organized. Dr. Lautenbacher noted issues related to interagency cooperation within the United States still exist as well.

Regulatory, legal, and policy issues with regard to intellectual property, standards, and trade

"Why and when do we need different standards? We don't need them and we shouldn't be developing them."

-Andrew Dearing

A second set of barriers to international collaboration involves international standards, intellectual property rights, and trade. Several presenters noted the far-reaching implications of these barriers and emphasized the need to address them. The Honorable Phillip J. Bond, Under Secretary for Technology, U.S. Department of Commerce, noted that 90 percent of the world's commodities in trade are impacted by standards policies. Mr. Michael Maibach, President and CEO of the European-American Business Council, noted that the European Union and United States represent about 10 percent of the world population, 40 percent of the world GDP, and 83 percent of all mergers and acquisitions.

The presentations of Mr. Bond, Mr. Maibach, Mr. Andrew Dearing, and Mr. Martin Mullins highlighted four major issues:

- **Patents:** The United States operates under a "first to file" system whereas the EU operates under a "first to invent" system. This may lead to differences in the length of protection under a patent, increased filing costs, and increased litigation.

- **Intellectual property:** In the United States, the Bayh-Dole Act governs the technology transfer from universities to the market in the United States; in the European Union, national intellectual property policies and in some cases individual university policies govern transfer. Although EU member states have moved toward adopting legislation similar to Bayh-Dole, discrepancies still exist. For example, the EU's FP6 rules require a mandatory 60-day notice before intellectual property can be transferred outside of the EU. During that time, the EU can decide whether or not to allow the transfer. This requirement has led to conflicts with global corporations that conduct research in EU countries. Given that these companies may have their own systems for transferring rights, the EU system can create conflict and slow the ability of companies to capitalize on innovations.

> *"If the energy companies on the one hand and the automotive companies on the other know that the things that they are developing will have universal application because they meet an international set of codes and standards, then clearly it will create a greater incentive for the sort of research that we will need from the private sector."*
> - Spencer Abraham

- **Visas:** Several workshop participants cited widespread anecdotal reports of researchers and students who have had difficulty moving in and out of the United States. Beyond these reports, Mr. Maibach noted specific concerns over the U.S. H1-B visas that are issued to foreigners who come to the United States to hold specialty positions, including research positions. Currently the United States allows 65,000 H1-B visas to be issued each year. In 2004, all 65,000 H1-B visas were issued on the first day of eligibility. This limitation has led to researchers being barred from entering the United States to conduct collaborative research.

- **Standards:** Mr. Maibach presented a cogent example of the impact of differing standards. As the result of the EU and United States having different safety and emissions standards for diesel engines, he noted, one company has indicated that it operates two R&D programs—one for the European Union market and one for the U.S. market. This duplication drives up the company's R&D costs because of the need to develop and test technologies under two separate sets of standards.

Three general recommendations for removing these barriers were discussed:

- **Talk now to avoid conflicts later:** Mr. Dearing noted that policies are difficult to change once they are established. Therefore, up-front discussions between all parties on issues such as those mentioned above could minimize future conflicts. For example, Mr. Maibach suggested that a pre-notification system for the transfer of IP rights should be established so that when a company engages in collaborations within the EU, there are no surprises when the research has been completed.

> *"We need to give our institutions and agencies both a mandate and the funding to reach closure on these issues if we expect them to do it. We can't just say that we want this to happen."*
> - Andrew Dearing

- **Engage all parties on specific ways to eliminate barriers:** Given that there may be resistance to change, parties on both sides must be presented with specific examples of how to eliminate barriers. Some of these were outlined by presenters, but many more merit examination. As noted by Mr. Dearing, if people are not provided with a system that is better than the current one, they will not want to move toward it. In many instances, industry should be involved in the discussion.

- **Be neutral and flexible, wherever possible:** Many participants strongly emphasized this position in light of the fact that science is an ever-changing enterprise. Mr. Dearing noted that R&D is driven by markets, skills, standards, and people. As patterns of investment and global networks change, systems will be needed to support and facilitate that change.

Mr. Mullins noted that despite these barriers, he and his colleagues have always been able to negotiate research agreements between the United States and the European Union. Nevertheless, while there is room for improvement, the gravity of the situation should not be overestimated. EURAB Member Dr. Soboll agreed and noted that when two partners have a common objective, they will find an agreement that will allow them to achieve it. Ultimately, both sides have the desire to stimulate research, work freely with others, and protect intellectual property rights.

Areas of Opportunity

- *Organizational changes within the European Union that will facilitate collaboration.*
- *Best practices that may support the development of future trans-Atlantic initiatives.*
- *Legal and regulatory discussions.*

Supporting National and International Research Priority Areas

At the heart of international scientific collaboration is a mutual interest in the conduct of science itself. Scientific and political leaders must identify areas that stand to fulfill scientific curiosity, scientific objectives, political objectives, and provide jobs and other economic benefits. Ongoing national and international initiatives provide a strong basis for identifying future areas for cooperation and as a result of them new mechanisms are emerging.

> *"I think this is very important—to recognize fully that science and technology are major drivers to increase relations at the economic and the political level."*
> - Mr. Pablo Ruiz

A framework already exists for collaboration between the EU and United States, namely the EU-U.S. Science and Technology Agreement, which was renewed on October 8, 2004 and extends through 2008. Although a recent Impact Assessment of the S&T Agreement found tangible benefits, it also noted that substantial progress is still needed to realize the full potential of this agreement.

In terms of future priority areas that may stimulate cooperation, Mr. Spencer Abraham commented on several initiatives at the Department of Energy and stressed the importance of international cooperation for achieving objectives. For example, through the International Partnership for the Hydrogen Economy, countries are working to develop international standards that may encourage industry to participate because research outputs and outcomes would then have universal application.

> *"We believe that these programs will definitely make a major contribution to meeting those goals, and[will]be more likely to do so if they are, in fact, international in scope."*
> - Spencer Abraham

Through President Bush's Clean Coal Power Initiative and FutureGen, international teams are working to develop the world's first clean coal power production facility that will produce both electricity and hydrogen simultaneously. Exciting opportunities and initiatives are also being developed though the Carbon Sequestration Leadership Forum. Each of these opportunities represents advances toward creating transformational and innovative technologies that will take energy efficiency to new levels in the 21st Century. Mr. Abraham stressed the need to engage the international community in the development of transformational technologies such as the next generation of nuclear power plants.

Mr. Ruiz outlined many of the research initiatives under FP6 and FP7. These include: biotechnology, fission and fusion research, nanotechnology, and information technology. In addition, Mr. Ruiz reiterated the importance of the International Partnership for the Hydrogen Economy, and the Carbon Sequestration Leadership Forum for driving international cooperation on energy research and development and also noted the continued move toward coordinated efforts within Europe, which is demonstrated through the technology platform being created by the European Research Area.

The workshop attendees discussed the effect of long-term planning documents on the identification of national and international research priority areas. U.S. government agencies such as the Department of Energy and the National Institutes of Health have created roadmaps to guide long-term strategic planning and funding. In 2004, President Bush outlined his Vision for Space Exploration and in 2005 NOAA completed its first 5-Year Research Plan and its 20-Year Research Vision. Through the FP, the EU also coordinates funding and priorities over an extended period of time. Since 1992, the Semiconductor Industry Association has updated its International Technology Roadmap for Semiconductors, which identifies trends and barriers in the semiconductor industry over a 15-year period.

Mr. Abraham discussed the implications and benefits of the Department of Energy's 20-year facility plan. In addition to setting priorities for facilities and communicating a vision to scientists, the plan provides a map to guide investments that may need to span Congressional and Presidential terms. Out of this roadmap also grew the identification of several international priority initiatives, including ITER, nanotechnology centers, and a supercomputing infrastructure.

"We should really determine first of all, before starting such a cooperation, the win-win situation. What are the common goals, the common objectives? And then I'm quite optimistic we will find the proper funding mechanisms."

- Horst Soboll

George Scalise, President of the Semiconductor Industry Association commented on the effectiveness of the International Technology Roadmap for Semiconductors in creating structure and consensus within the community and setting an international standard. EURAB Member Dr. Jens Rostrup-Nielsen noted the use of technology platforms in the EU, which allow stakeholders to engage in a formal dialogue that can result in the development of a roadmap.

Dr. Rostrup-Nielsen suggested that the pursuit of these technology platforms through U.S.-EU collaboration could allow each side to exchange visions and coordinate opportunities for research. Several participants noted examples where this approach has been effective already. EURAB Member, Dr. Horst Soboll, referred to the FreedomCAR program, where the Department of Energy and the United States Council for Automotive Research (USCAR)—a partnership of Ford Motor Company, DaimlerChrysler, and General Motors—agreed on an objective and then drafted an arrangement that will allow that objective to be met; in this case, hydrogen-powered transportation. Mr. Ruiz added that the International Partnership for the Hydrogen Economy and Carbon Sequestration Leadership Forum followed the same type of approach—international parties agreed on a common objective and then worked together to identify technological incentives and other ways to achieve that objective.

Mr. Kvamme queried individuals from both the EU and the United States as to the possibility and benefits of having the EU and United States coordinate long-term plans between mechanisms such as the FP and, for example, the Department of Energy roadmap. EU and U.S. participants were excited by and interest in the possibilities inherent in this idea while understanding that ultimately such coordination would depend on the efforts of national policymakers.

Today's reality is that many of these opportunities in science and technology and many of the societal challenges, such as in the environment, natural hazards and health, as well as breakthroughs in discovery science, can only be addressed in an international framework.

- Kathie L. Olsen

Given the global scale, impact, and interest of many of today scientific research issues—climate change, space exploration, bioterrorism, and nanotechnology—international cooperation is of mutual interest and benefit because it reduces the costs and burdens on any one party. With the emergence of mechanisms such as the EU Framework Program and the various U.S. roadmaps described above, these long-term initiatives may serve as the basis for forming future partnerships to complement the already robust EU-U.S. cooperation.

Areas of Opportunity

- *Mechanisms that have allowed international initiatives, such as the International Partnership for the Hydrogen Economy and FreedomCAR to be successful.*
- *Potential to coordinate future planning documents between the United States and EU to help identify areas for collaboration.*
- *Benefits and drawbacks to communicating long-term plans through roadmaps.*

Summary Observations on Trends in International Collaboration

From space exploration and high energy physics, to ground-based telescopes and biotechnology, cooperative efforts between the United States and the European Union have led to scientific breakthroughs, economic benefits, and perhaps most importantly, strong friendships at many levels with important implications for global prosperity.

However, successful transatlantic scientific cooperation encompasses more than the science itself. Although the PCAST Workshop on S&T Collaboration: Ideas for Enhancing European-American Cooperation successfully stimulated a candid discussion of key barriers to collaboration, other barriers remain unaddressed.[5] Changes in the way scientific research is conducted and managed and changes within scientific disciplines themselves all create challenges and opportunities.

Many of today's global social challenges—climate change, safe and sustainable sources of energy and water, bioterrorism, and human health—require levels of knowledge, facilities, and funding that are beyond the scope of a single organization or nation. These are the issues that transatlantic international collaborative research frameworks can and must address. Though science is a global enterprise, the transatlantic focus of this workshop served to identify ways to eliminate barriers and expand future cooperation between the United States and the European Union.

In the spirit of sustaining and enhancing EU-U.S. cooperation, PCAST acknowledges all the panelists and participants, in particular members of EURAB, who contributed to a lively discussion.

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Appendix A:
Information Brief on Recent Patterns of US and European R&D Investment

Background

- Important changes have taken place in recent years in national patterns of research and development (R&D).
  - Industrial R&D investment has outpaced government R&D spending in most industrialized nations.
  - Changes have likewise taken place in the locus of the performance of R&D with greater evidence for industrial-based R&D.
- The United States continues to lead the world in the relative share of gross domestic expenditure in R&D (GERD).
- However, many European countries have committed to increasing their R&D budgets to stimulate economic productivity, especially through the 7th Framework Programme of the European Union.

Introduction

Each year for the past 40+ years, the United States has invested 2-3% of its gross domestic product in research and development (R&D). Around 1980, the industrial sector surpassed the Federal government as the primary source of R&D support in the United States. In 2002, total national investment in R&D reached a level of about $280 billion in the United States, two-thirds of which ($181 billion) represented industrial investment in R&D activities. Changes have also taken place with respect to the relative mix of sectors performing R&D (e.g., industry, government, and academia); levels of investment in basic research as compared to applied research; and the changing nature of development. Similar changes in national R&D funding patterns have taken place around the globe.

This brief compares contemporary patterns of R&D investment between the United States and selected European countries.[6]

The brief is organized into four sections. The first presents a brief overview of international patterns in R&D investment, including the identification of key countries selected for analysis. The subsequent sections present comparative statistics on trends in gross domestic expenditure on R&D (GERD), the relative mix of R&D performers for selected countries, and recent developments in national patterns of investment as determined by the "character" of the R&D being conducted.

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6 The information presented in this brief has been drawn largely from OECD 2004 and NSB 2004.

Context

Both the United States and Europe have a long history of investment in R&D, here defined as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications." (OECD 2002) In recent years, the U.S. Federal Government has emphasized investment in R&D as a means to strengthen national security, develop energy independence, improve the economy, address workforce needs, and enhance human health (Marburger and Bolten 2004; Davey 2004), while industrial R&D investment has tended to reflect a concern with international competitiveness (NSB 2004, 4-11). Although R&D investment strategies vary among Organization for Economic Cooperation and Development (OECD) member countries, R&D investment in those countries is strongly linked with high-technology goods and services (NSB 2004, 4-50).

The European Union (EU) also provides a mechanism for funding research in Europe through its "Framework Programme." The Sixth Framework Programme (FP6) is "open to all public and private entities, large or small" and covers a four-year period that began in 2003 and will conclude in 2006 (European Commission 2002). FP6 includes seven key areas for the advancement of knowledge and technological progress: genomics and biotechnology; information society technologies; nanotechnologies and nanosciences; aeronautics and space; food safety; sustainable development; and economic and social sciences. The overall budget for FP6 for the four-year period exceeds 17 billion, which is a 17% increase from the Fifth Framework Programme.

The OECD maintains a database that is widely considered to be the most reliable source of information for comparing international R&D investment. Their estimates for the total R&D investment of the 30 OECD member countries (see Table 1) in 2002 was $650 billion; however, 86% of that was accounted for by seven member countries (United States, Japan, Germany, France, U.K., Korea, and Canada). Although the United States has consistently remained the world leader in R&D investment, plans by European nations to strengthen their economies through innovation suggests that the relative share of world R&D investment may change in the coming years. [7]

Table 1:
Current Members of the OECD

Current Members of the OECD

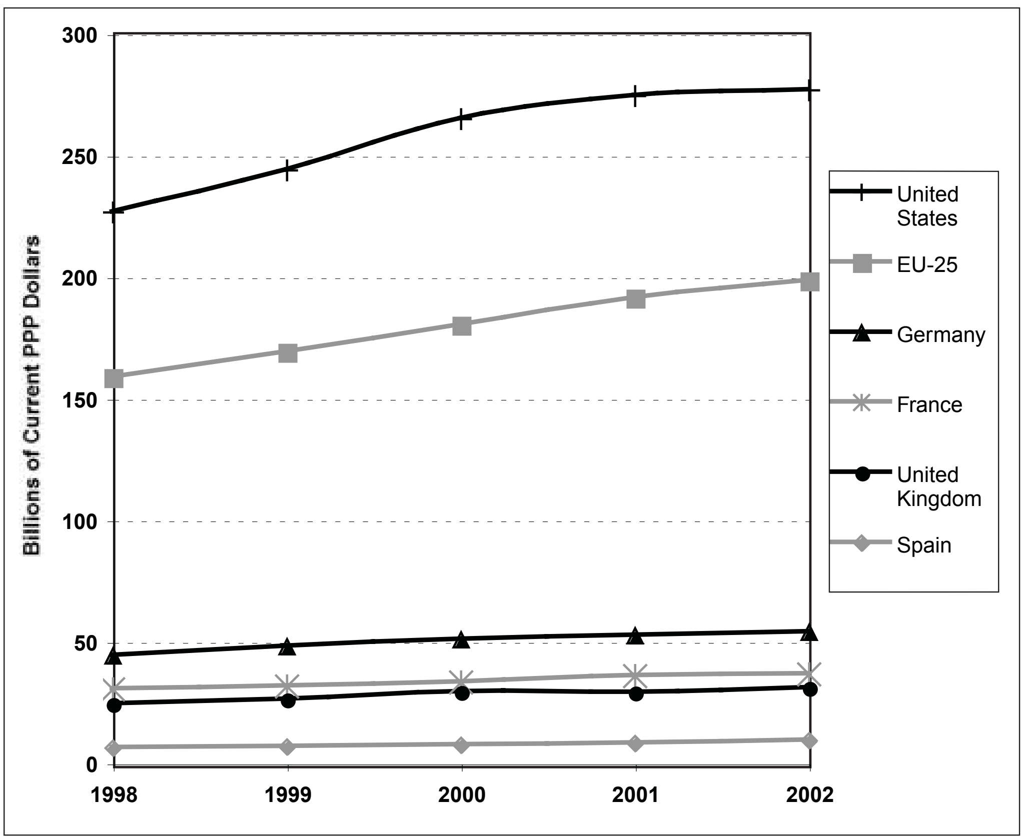
Australia	Hungary	Norway
Austria	Iceland	Poland
Belgium	Ireland	Portugal
Canada	Italy	Slovak Republic
Czech Republic	Japan	Spain
Denmark	Korea	Sweden
Finland	Luxembourg	Switzerland
France	Mexico	Turkey
Germany	Netherlands	United Kingdom
Greece	New Zealand	United States

[7] These estimates are based on reported R&D investments converted to U.S. dollars using purchasing power parity (PPP) exchange rates. For a discussion of how PPP is calculated, see NSB 2004, 4-48.

Relative Trends in R&D Investment

Absolute levels of R&D expenditures reveal a country's innovative capacity and are indicators of potential future growth and productivity. Between 1998 and 2002, the United States and Europe both demonstrated nominal increase in their respective GERD (see Figure 1).

In 2002, U.S. R&D expenditure totaled $280 billion, which was 43% of the OECD total of $650 billion. However, R&D investments in the United States are approximately 40% greater than R&D investments made by the European Union and 5 times greater than Germany, which is the largest performer of R&D in Europe. Between 1998 and 2002, the United States increased its R&D expenditure, but from 2001 to 2002, the percentage increase (0.9%) was considerably lower than that of the European Union countries (3.7%) as well as OECD member countries (2.4%). Spain, furthermore, increased its R&D expenditure at a higher rate than the European Union average each year from 1999 to 2002.



Source: OECFD, Main Science and Technology Indicators, May 2004. STPI Tabulation.

Figure 1. Gross domestic expenditure on R&D (GERD) for selected countries.

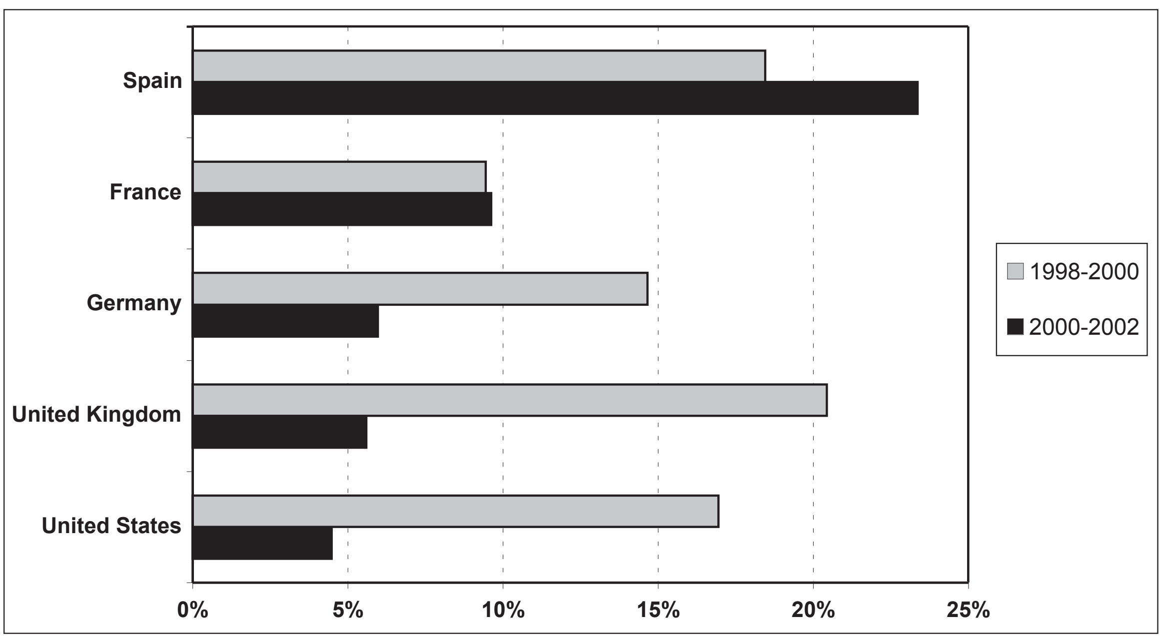
Growth rates in GERD for various OECD countries and the OECD as a whole have been positive in recent years (see Figure 2). GERD growth slowed significantly in both the United States and Germany in the period between 2000 and 2002 compared to between 1998 and 2000. GERD growth also slowed for both the OECD and European Union nations over this period, but not as dramatically as it did in the United States.

GERD as a percentage of GDP is a ratio that reveals the intensity of R&D activity compared to other economic activity (see Figure 3). It is often used as a relative measure of a nation's dedication to R&D. In 2002, Finland was the only European country that spent a larger percentage (3.5%) of GDP than the United States did (2.7%) on R&D. The percentage among OECD nations (2.3%) is slightly lower than the U.S. percentage.

R&D Performers

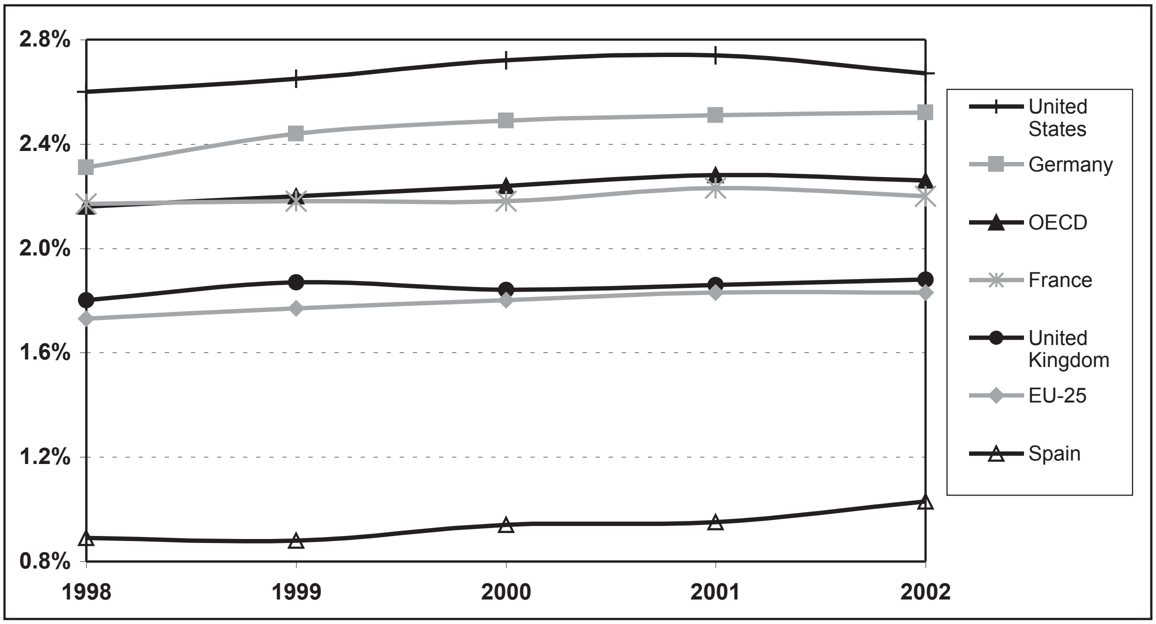
> *Since 1955, industry has performed the majority (between 68 and 78%) of the R&D in the United States. Between 1955 and 1978, the Federal government was the second highest performer in R&D followed by universities and colleges. In 1979, universities and colleges surpassed the Federal government in performer share; they continue to be the second highest performer to date (see Figure 4).*

As the figure shows, from 1998 to 2002 the industry share of R&D investment decreased, although it continued to represent more than 70% of all R&D performed in the United States. During the same period, the R&D performance of universities and colleges, the Federal Government, and other non-profit organizations all increased.



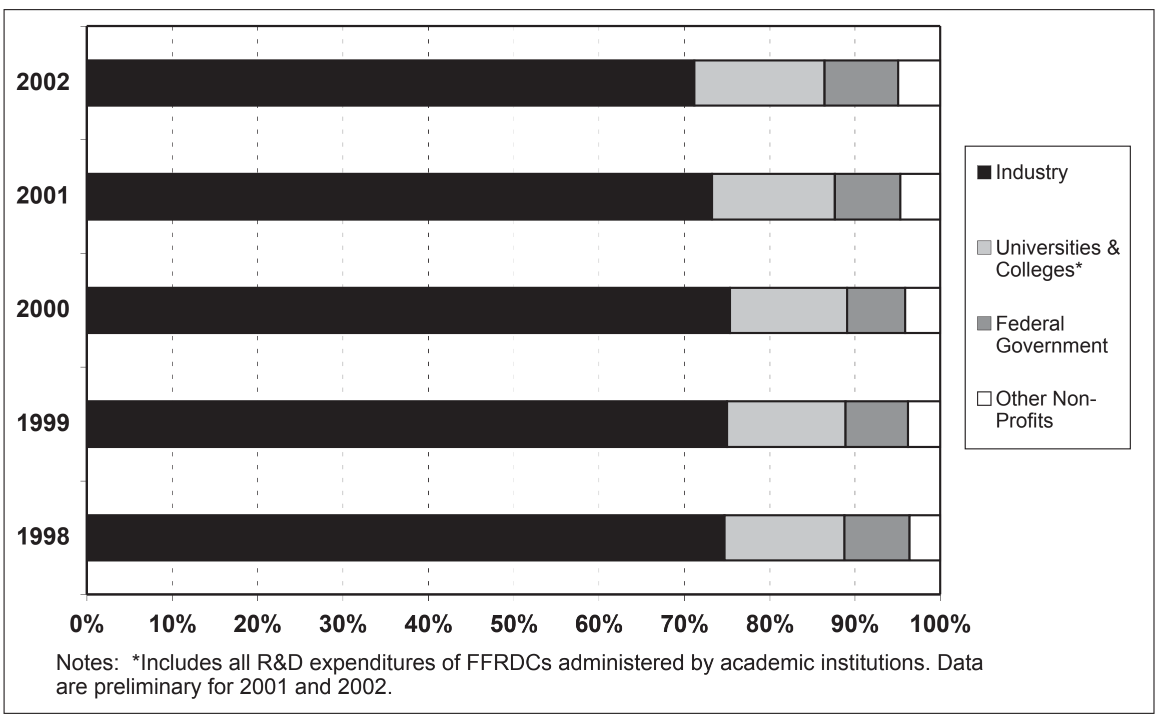
Source: OECFD, Main Science and Technology Indicators, May 2004. STPI Tabulation.

Figure 2. Percent change in GERD for selected countries.



Source: OECFD, Main Science and Technology Indicators, May 2004. STPI Tabulation.

Figure 3. GERD as a percentage of gross domestic product (GDP) for selected countries.



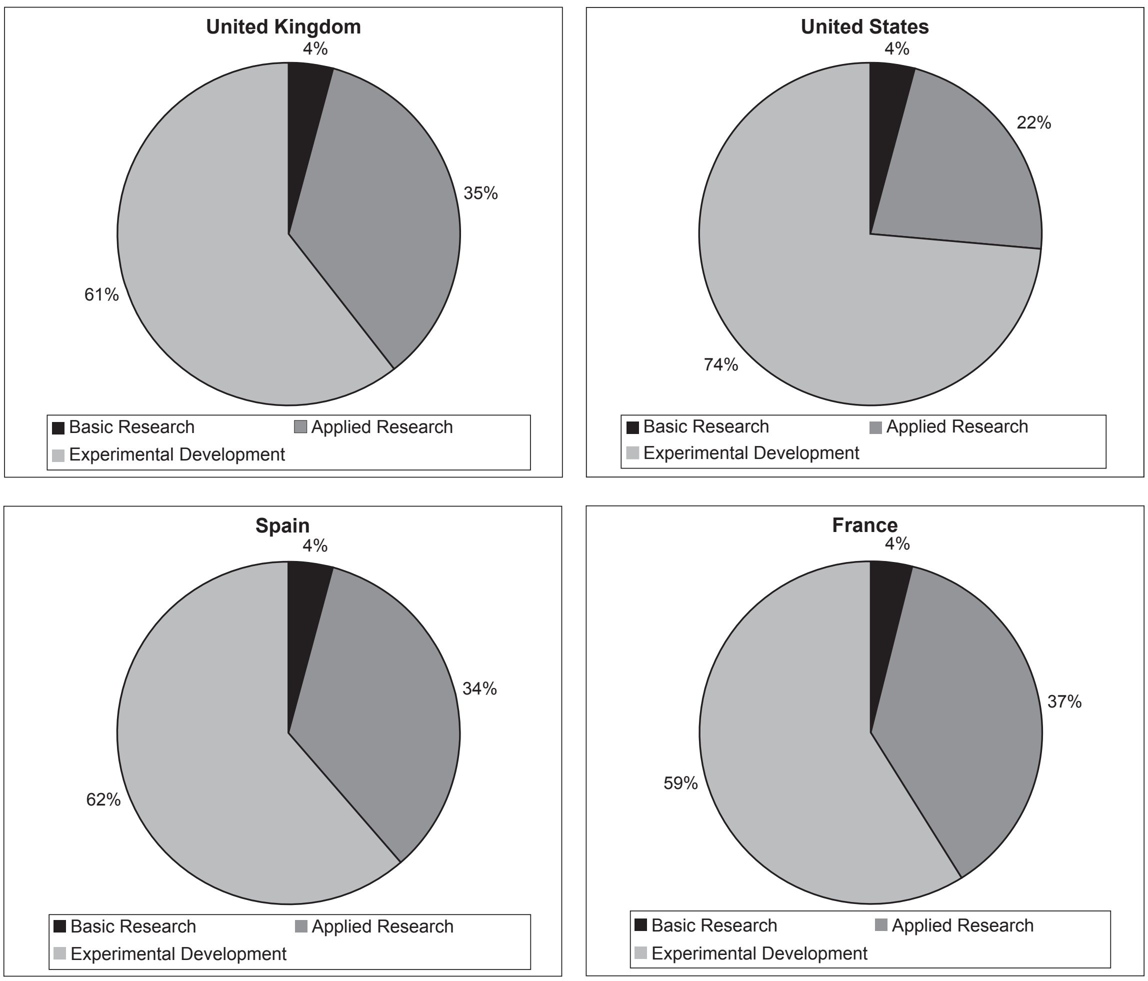
Source: NSF, Science & Engineering Indicators 2004. STPI Tabulation.

Figure 4. R&D expenditure by performer share.

“Character” of R&D

R&D is traditionally divided into three categories: basic research, applied research, and experimental development. Although specific R&D projects can be difficult to classify, analysis of the distribution of a country’s R&D activities is a useful method for identifying the categories in which that country prefers to innovate (see Figure 5).

As Figure 5 shows, in 2001 the United States, the United Kingdom, France, and Spain all showed strong dedication to applied research and development. However, in the U.K., France, and Spain, the ratio of applied research to experimental development was higher than in the United States.



Source: OECD, Research and Development Statistics, 2003. STPI Tabulation.

Figure 5. Character of R&D for selected countries, 2001.

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Appendix B: Information Brief on Measuring Collaborative Science Efforts

Background

- In recent years, international collaboration in science, technology, and engineering programs has increased significantly.
- Rising numbers of advanced science and engineering (S&E) degrees awarded at U.S. universities primarily reflects an increase in the number of foreign students.
  - Following the terrorist attacks of September 11th, 2001, enrollment in S&E fields declined significantly.
- U.S. authors publish the greatest number of internationally co-authored S&E articles.
- The number of large-scale international science projects is steadily increasing.

Introduction

Collaboration across national borders, specifically between the United States and Europe, has increased significantly in recent years. The effects of this increase are reflected at all levels of traditional collaborative activity, from graduate student enrollment and doctoral degree awards to journal co-authorship and multinational projects. The increase appears to be driven by several highly inter-related factors:

- **Scientific need:** Cutting edge science today is more likely to be interdisciplinary in nature. Furthermore, "the scope, cost, and complexity of some of today's scientific problems, such as mapping of the human genome, studying global environmental trends, or constructing an observatory in space invite and often compel domestic and international collaboration." (NSB 2004, 5-43)
- **Technological advances:** Telephone and Internet communications and air travel have tremendously reduced the financial cost of international collaboration. Email, in particular, has played a facilitating role.
- **Education:** "Study aboard appears to contribute to growth in international collaboration. Relationships established between foreign students and their teachers can form the basis of future collaboration after the students return to their native country. As an important supporting element in other factors driving collaboration, information technology greatly facilitates this type of collaboration." (NSB 2004, 5-43)
- **Falling political barriers:** "The end of the Cold War allowed countries to establish and/or renew political, economic and scientific ties. It also led the addition of new...countries." (NSB 2004, 5-43)

- **Government policies:** Many nations have adopted policies that encourage scientific collaboration to maximize the country's national investment in research and development (R&D), to advance progress in science and technology (S&T), to further domestic capability, and to speed the transfer of knowledge. Some countries have adopted national R&D funding requirements that encourage or even require international collaboration and formal cooperative S&T agreements with other countries.

The combination of these factors has ensured availability of funding from both U.S. and European sources for collaborative efforts among their scientists and engineers. These efforts include scholarships, fellowships, and grants for graduate studies as well as collaborative research projects. Numerous international research facilities actively seek to bring together thoughts and ideas from around the world.

Although most measures of collaboration between the United States and countries in Europe show positive developments in recent years, the social and economic impacts resulting from the events of September 11th, 2001, have introduced new uncertainties; for example, preliminary data show that first-time enrollment of students on temporary visas fell significantly in 2002—an impact that could weaken collaboration in other areas. Long-term effects will likely not be fully visible for years.

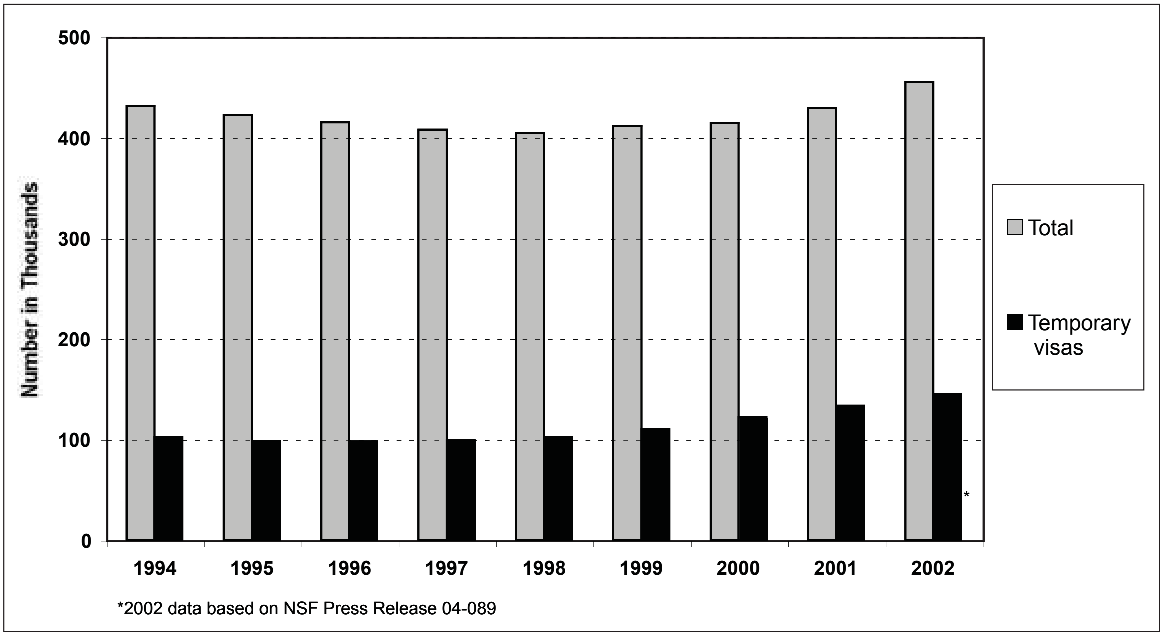
This brief examines the major factors influencing international collaboration today, in order to identify emerging trends in collaborative practice. The information contained in this brief is presented in three sections. The first section reviews collaborative efforts in education and training. The second section focuses on professional collaboration across countries. The final section reviews multinational projects. The data discussed in each section are presented in chart form with narrative summaries for each of the charts.

Collaboration in Education and Training

This section reviews collaboration in education and training from three perspectives: levels of graduate enrollment; the effects of the September 11th, 2001, terrorist attacks; and trends in U.S. and European doctorates awarded to students with temporary visas. Each of these three perspectives is treated separately below.

Graduate Enrollment

A rise in the number of advanced science and engineering (S&E) degrees awarded at U.S. universities reflects, primarily, significant increases in the number of foreign students. After decreasing for four years in a row beginning in 1994, the number of S&E graduate students in the United States grew every year from 1998 to 2002, when it reached 455,400 and finally surpassed the 1994 level (see Figure 6). From 1997 to 1998, enrollment in electrical engineering and computer science increased by 2.5% and 5.1% respectively, while concurrently declining in industrial engineering, civil engineering, and social sciences by 5.8%, 4.0%, and 2.6% respectively. From 1998 to 1999, enrollment in computer science increased 12% —the only science field to increase by more than 1% during that time. Engineering enrollment rose by 1% due to increases in aerospace, electrical, mechanical, biomedical, and petroleum engineering enrollment. However, enrollment in larger engineering fields—namely, chemical, civil, and industrial—continued to decline.

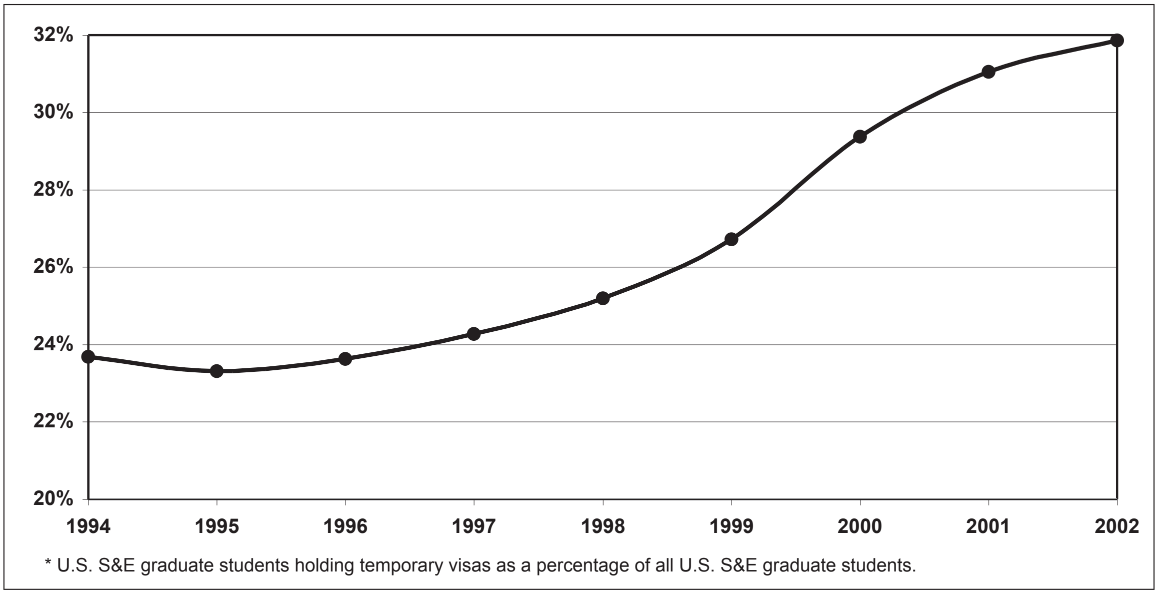


Source: NSF, Division of Science Resources Statistics, Graduate Students and Postdocturates in Science and Engineering: Fall 2001. STPI Tabulation.

Figure 6. U.S. science and engineering (S&E) graduate student enrollment.

Engineering and mathematical sciences led in percentage gains in 2002, both rising more than 9% over the preceding year. Other fast-growing fields were the computer and biological sciences, which each increased by 6%. In 2002, the S&E fields with the highest proportions of temporary visa holders were: engineering (49%); computer sciences (48%); physical sciences (40%); and mathematical sciences (39%). Those fields with the lowest proportions were: social sciences (20%); earth, atmospheric and ocean sciences (19%); and psychology (6%).

The percentage of U.S. S&E graduate students with temporary visas has gradually climbed since 1996 to the point where almost one third of all U.S. S&E graduate students hold temporary visas (see Figure 7). From 2000 to 2001, the number of computer science and engineering graduate students with temporary visas increased by 16% and 11% respectively. In 2001, students with temporary visas made up almost half of the graduate students in computer science and engineering.



Source: NSF, Division of Science Resources Statistics, Graduate Students and Postdocturates in Science and Engineering: Fall 2001. STPI Tabulation.

Figure 7. Foreign share of S&E graduate students holding temporary visas as a percentage of all U.S. S&E graduate students.

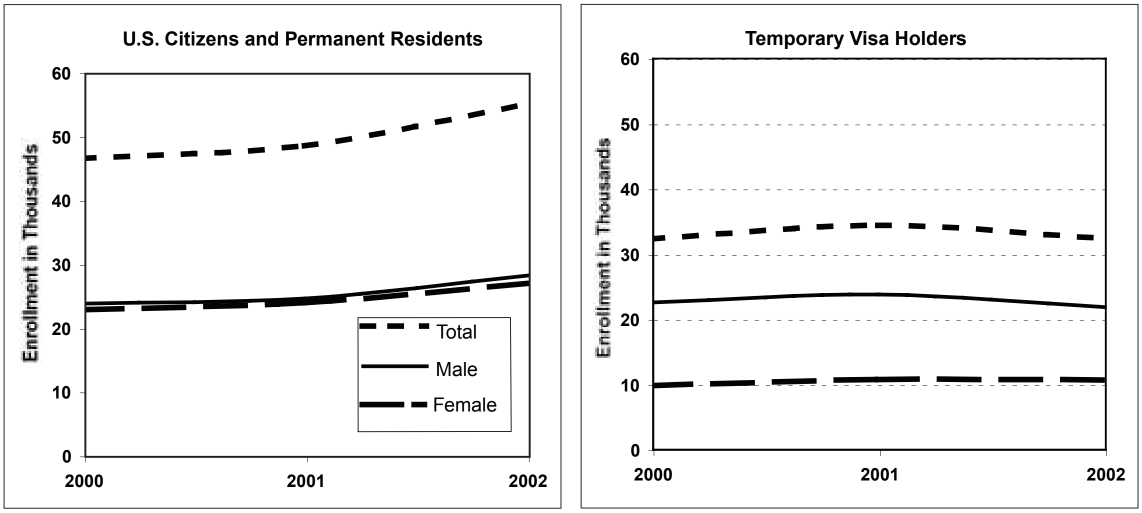
There are at least 42 international scholarships and fellowships that provide funding for American students studying in Europe and European students studying in the United States. They provide different amounts of support and vary in length and eligibility criteria. One example is the International Research Fellowship Program (IRFP) funded by the National Science Foundation (NSF). This program provides between 30 and 35 students with annual support totaling approximately $3.5 million. Students are funded for up to 24 months at institutions of higher education as well as industrial, non-profit, and government research centers. In addition to NSF, the National Institutes of Heath (NIH) provides a large number of international students with financial assistance.[8]

The Effects of September 11th, 2001

Following the terrorist attacks of September 11th, 2001, enrollment in S&E fields declined significantly. The first data on graduate S&E enrollment since the attacks show that the enrollment of full-time, first-time foreign graduate students declined by about 2,100, or 7.9%, in 2002 (see Figure 8). The largest decreases in full-time, first-time enrollment of graduate students on temporary visas were in computer sciences (almost 15%) and earth, atmospheric, and ocean sciences (about 8%).

The overall decrease primarily reflects a significant drop in first-time enrollment of male S&E graduate students on temporary visas (8.1%); enrollment among their female counterparts dropped only 1.2%. The large increase in the number of U.S. citizens and permanent residents entering U.S. S&E graduate programs (13.6% between 2001 and 2002 as compared to 4.1% between 2000 and 2001) may be due in part to fewer applications by, or lower admissions rates of, students on temporary visas. NSF also reported evidence of

[8] The European Union offers a similar variety of scholarships to promote international exchange among students, including for example the Marie Curie Fellowship Program.



Source: NSF, Division of Science Resources Statistics, Survey of Graduate Students and Postdocturates in Science and Engineering, 2002.

Figure 8. Full-time, first-time graduate student enrollment in S&E (legend applies to both tables).

fewer student and exchange visas being granted. In addition, slower or more critical visa processing and changing economic conditions also may have contributed to this trend.

Despite these significant decreases, both the total graduate enrollment in U.S. S&E programs and the percentage of U.S. S&E graduate students with temporary visas have increased between 1998 and 2002. This means that a greater number of students with temporary visas who enrolled prior to 2002 elected to stay than have done so in the past, perhaps extending the length of time it will take them to earn their degrees.

As the National Science Board (NSB 2004, 2-41) observed:

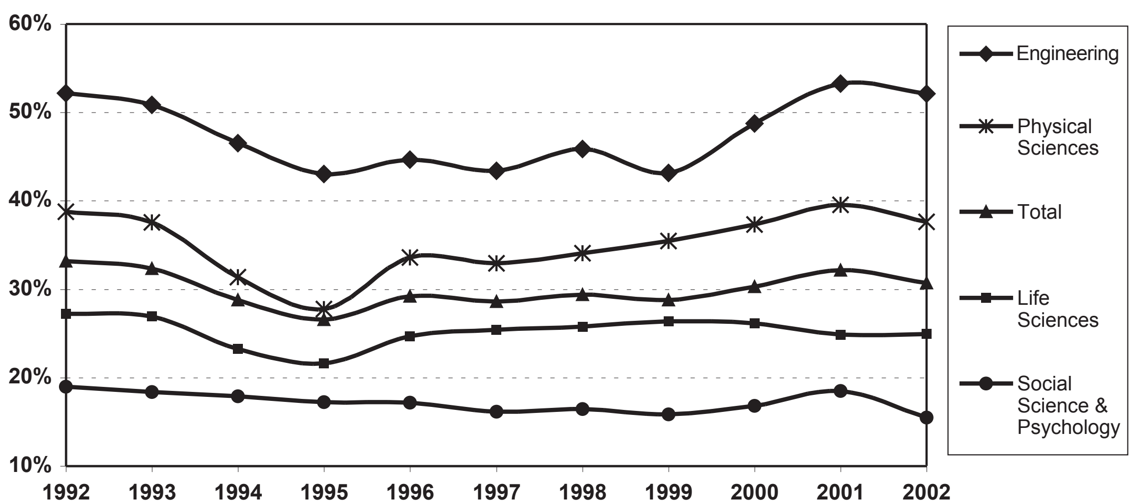
> *"These developments occur in the context of continuing extension of global markets; worldwide reach of networks of scientific and technical activity, cooperation, and competition; and global flows of highly trained personnel. As government efforts to develop centers of excellence bear fruit, and as industry locates in developing markets and regions with newly developed technological competency, continuing shifts will take place in the international distribution of jobs and employment requiring high skill levels and technically sophisticated training. The shifts will, in turn, elicit responses from worldwide higher education systems."*

Trends in U.S. and European Doctorates Awarded to Students with Temporary Visas

Through 2001, ever-increasing numbers of foreign students came to the United States to study and to stay upon completion of their studies. During the late 1990s, the rate at which doctoral students stayed after earning their doctorate here rose well above the longer-term averages. Between 1998 and 2001, 76% of foreign doctoral students reported that they planned to stay in the United States upon completing their degree; 54% had firm commitments to do so.

Engineering and physical sciences awarded the highest percentage of doctoral degrees to foreign students in every year from 1992 to 2002 (see Figure 9). Among the physical sciences, mathematics and computer science had the highest percentage of foreign doctorates awarded. Every year between 1992 and 2002, over 41% of U.S. engineering doctorates were awarded to non-U.S. citizens with temporary visas; in 1992, 1993, 2001, and 2002 that number was more than 50%. U.S. citizens and permanent residents earned over 80% of the social science and psychology doctorates awarded between 1992 and 2002. However, the total number of doctorates earned at U.S. schools by students on temporary visas fell in 2002, perhaps partly due to withdrawals or extended stays following the events of September 11th, 2001.

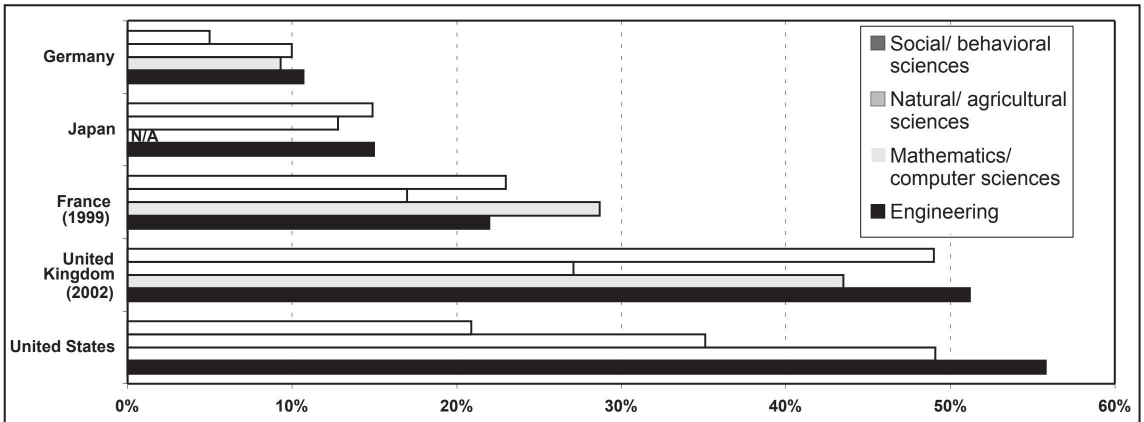
In 2001, foreign students earned 56% of the engineering degrees awarded by U.S. universities, compared to 51% of those awarded by U.K. universities and 22% of those awarded by French universities (see Figure 10). Foreign students earned 49% of the mathematics and computer science doctorates awarded by U.S. universities, 44% of those awarded by U.K. universities, and 29% of those awarded by French universities. In addition, Japan and Germany had modest but growing percentages of foreign students among their S&E doctoral degree recipients. By 2001, around 36% of S&E doctorates from U.K. and U.S. universities were awarded to foreign students. Almost 21 percent of French S&E doctoral recipients were foreign.



Notes: Physical sciences include mathematics, computer science, physics and astronomy, chemistry, earth, atmospheric & ocean sciences. Life sciences include biological sciences, agricultural sciences, and health sciences.

Source: NSF, Survey of Earned Doctorates, Doctorate Recipients from United States Universities: Summary Report 2002. STPI Tabulation.

Figure 9. Percent of U.S. doctorates earned by non-U.S. citizens with temporary visas.



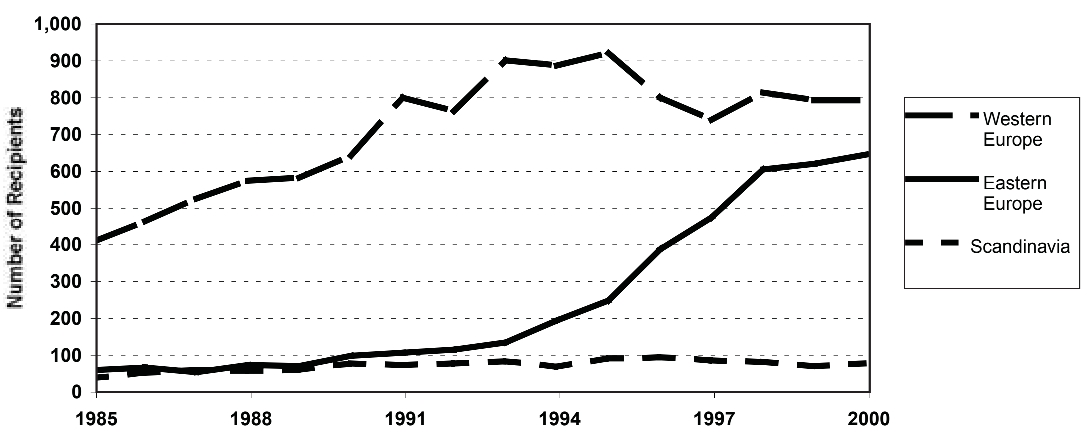
Notes: N/A = Not Available. Japanese data are for university-based doctorates only; excludes ronbun hakase doctorates awarded for research within industry. Japanese data include mathematics in natural sciences and computer sciences in engineering. For each country, data are for doctoral degree recipients with foreign citizenship, including permanent and temporary residents. Natural sciences include physical, biological, earth, atmospheric, and ocean sciences.

Source: NSF, Science and Engineering Indicators 2004, Figure 2-40

Figure 10. S&E doctoral degrees earned by foreign students from selected countries.

Doctoral degrees earned by Eastern Europeans at U.S. schools increased dramatically a few years after the end of the Cold War as the countries in these regions re-established ties with the West (see Figure 11).

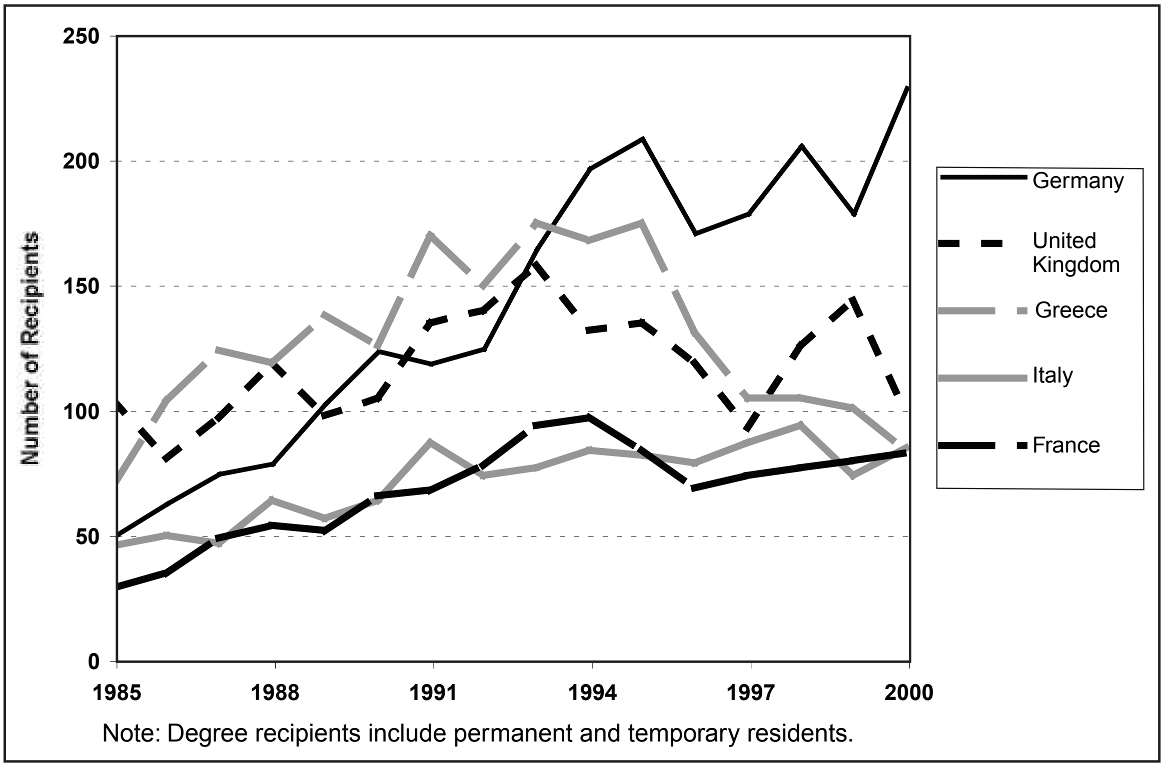
Between 1985 and 2000, students from Germany, Greece, the U.K., Italy, and France—in that order—earned the most doctorates awarded in the United States to Western European students (see Figure 12). Greece and the U.K. led the list between 1985 and 1993, but the number of students from those countries declined. Meanwhile, Germany was the only country whose students earned an increasing number of U.S. doctorates



Notes: Degree recipients include permanent and temporary residents. Western Europe includes Andorra, Austria, Belgium, France, Germany, Gibraltar, Greece, Ireland, Italy, Luxembourg, Malta, Monaco, Netherlands, Portugal, Spain, and Switzerland. Eastern Europe includes Albania, Bulgaria, Czech Republic, Slovakia, Hungary, Poland, Romania, Russia, Armenia, Azerbaijan, Belarus, Estonia, Georgia, Kazakhstan, Kyrgystan, Latvia, Moldova, Tadjikistan, Turkmenistan, Ukraine, Uzbekistan, Yugoslavia, Bosnia-Herzogovina, Croatia, Macedonia, and Serbia-Montenegro. Scandinavia includes Denmark, Finland, Iceland, Norwa y, and Sweden.

Source: NSF, Science and Engineering Indicators 2004, Figure 2-28

Figure 11. U.S. S&E doctoral degree recipients from Europe, by region.



Source: NSF, Science and Engineering Indicators 2004, Figure 2-28

Figure 12. U.S. S&E doctoral degree recipients from Europe, by region.

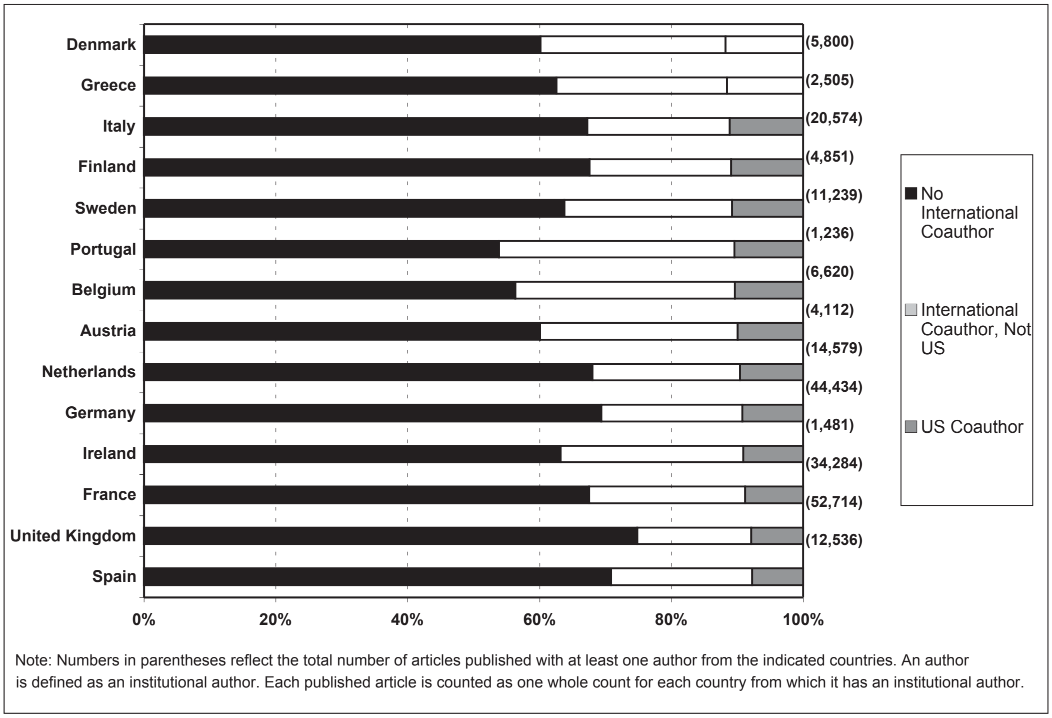
throughout the 1990s. In U.K. universities, Germans represent the largest percentage of foreign-born doctoral recipients. This could be due to the shorter duration of U.K. and U.S. degree programs as compared to those in German universities. (NSB 2004, 2-32)

Grants and fellowships are the most typical forms of support for post-doctorates. Like graduate students, post-docs who seek to conduct research in another country have a number of different grants and fellowships available to them. For example, the Alexander von Humboldt Foundation offers the Humboldt Research Fellowship to post-doctorates under the age of 40. The program provides stipends of up to 3,000 per month for international fellows conducting research at German institutions.

Professional Collaboration Across National Boundaries

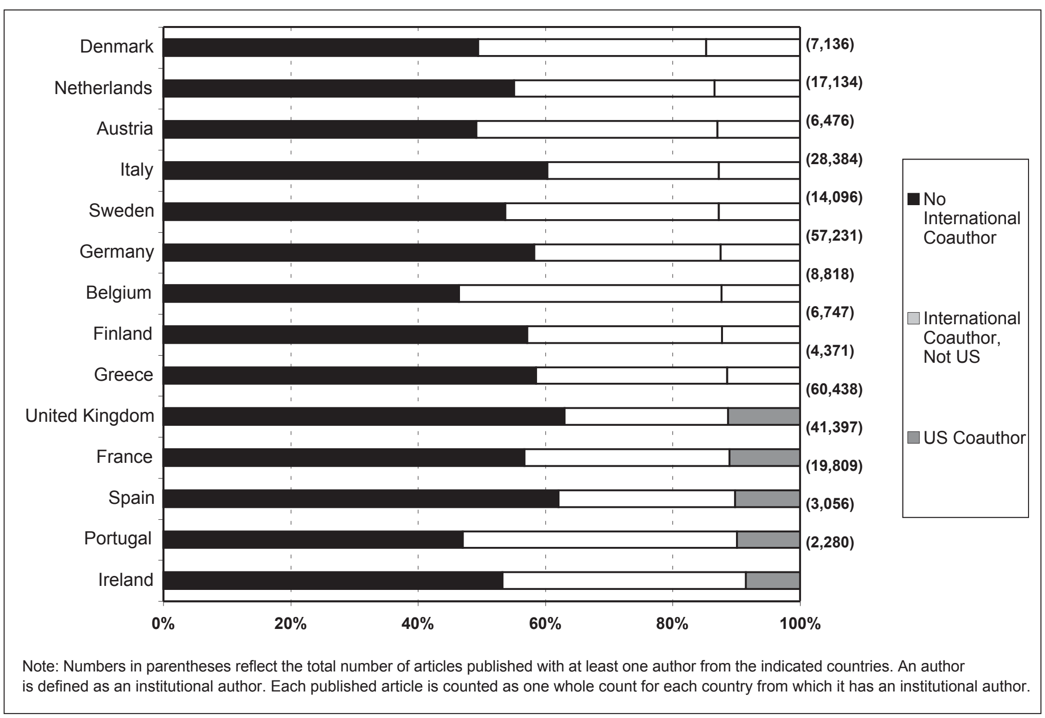
One of the most valuable methods for tracking international professional collaboration is to examine trends in co-authorship among authors from different countries. In 2001, U.S. citizens authored 228,051 articles, of which 23.2% were coauthored with representatives from at least one foreign country, a dramatic increase from 1998 when only 10.3% of 177,662 U.S. articles were internationally co-authored (see Figures 13a and 13b).

In 2001, German, U.K., Canadian, Japanese, French, and Italian citizens coauthored the greatest number of articles with colleagues from the United States. A significantly higher percentage of European articles are coauthored both with the United States and with other countries in 2001 compared to 1994.



Source: NSF, Science and Engineering Indicators 2004, STPI Tabulation

Figure 13a. Share of articles with international coauthor, 1994, by country.



Source: NSF, Science and Engineering Indicators 2004, STPI Tabulation

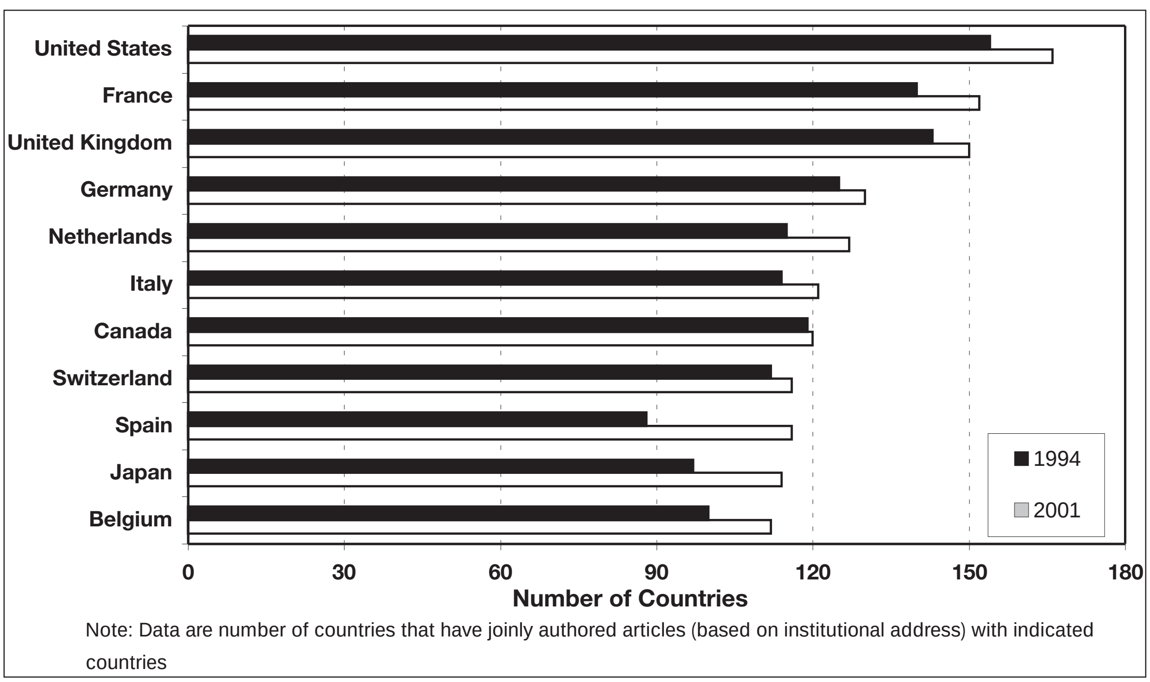
Figure 13b. Share of articles with international coauthor, 2001, by country.

U.S. authors continue to publish the greatest number of internationally co-authored articles. European countries comprise nine of the top twelve leaders on this list (see Figure 14). Following the end of the Cold War, the establishment in the 1990s of new Eastern European countries subsequent to the Cold War increased the number of countries from which authors could collaborate with colleagues in another country. U.S. authors collaborated with authors from 166 of the 180 countries whose citizens collaborated on any scientific article in 2001. U.S. scientists collaborated in 18% to 42% of the internationally coauthored articles with citizens of most Western European countries. In terms of the emerging and developing nations, U.S. collaboration is also significant and tends to be relatively high with authors from countries with significant regional output, except in Eastern Europe where the U.S. share is generally lower than that of most other countries.

The patterns of international collaboration with the United States also appear to reflect the ties of foreign students who received advanced training in the United States. As Figure 15 shows, there is a moderately high correlation (r2 = 0.45) between the number of U.S. PhDs awarded by country to foreign-born students in 1992-1996 and the volume of papers coauthored by the United States and those countries in 1997-2001. (NSB 2004, 5-43)

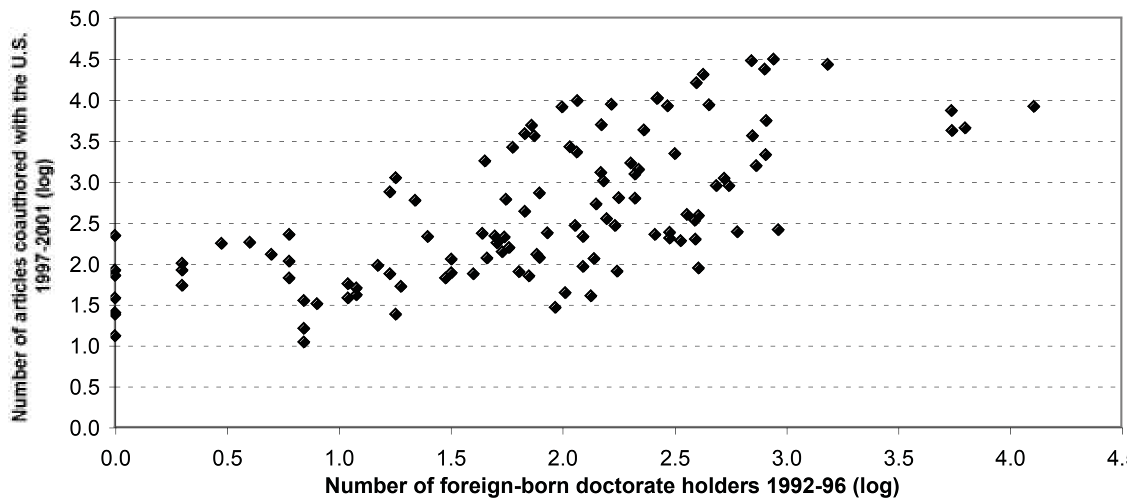
As the National Science Board (NSB 2004, 5-43) recently observed:

> *"Study aboard appears to contribute to growth in international collaboration. Relationships established between foreign students and their teachers can form the basis of future collaboration after the students return to their native country. As an important supporting element in other factors driving collaboration, information technology greatly facilitates this type of collaboration."*



Source: NSF, Science and Technology Indicators 2004, Table 5-22

Figure 14. Breadth of international S&E collaboration.



Notes: R^2 = 0.45. Countries with at least 0.02 percent share of internationally coauthored articles are included. Coauthored articles are on the basis of whole counts, where each country is assigned an entire count for coauthorship on an S&E article with the United States.

Source: NSF, Science and Engineering Indicators 2004, Table 5-39

Figure 15. Relationship of advanced training to international collaboration with U.S. authors.

Multi-National Projects

Given the complexity of today's scientific problems and the high cost of research necessary to solve them, the advantages of combining resources, ideas, and economic efforts among nations—the establishment, in other words, of large-scale international science projects—is self-evident. Large-scale international science projects are those in which two or more countries formally agree to cooperate in attempting to achieve a scientific, R&D, or engineering goal (Shore and Cross 2003) The European Organization for Nuclear Research (CERN), for example, exists primarily to provide physicists with tools such as particle accelerators and particle detectors that are necessary for their work. CERN is run by a cooperative consisting of 20 European member states that contribute to the capital and operating costs of CERN's programs, and are responsible for all important decisions about the organization and its activities. CERN hosts a wide range of collaborative efforts. The United States is among the 35 non-member states, observer states, and organizations that are currently involved in CERN programs. Scientists from 220 institutes and universities of non-members states use these facilities. Since 1997, CERN has been working on the Large Hadron Collider (LHC), the world's largest and most powerful particle accelerator. The United States is expected to fund a total of $531 million of which $450 million will be from the Department of Energy (DOE) and $81 million will be from the National Science Foundation (NSF). This represents about 1/12 of the $6 billion project budget.[9] (OMB 1999)

The International Thermonuclear Experimental Reactor (ITER) will be the first fusion device to produce thermal energy at the level of an electricity-producing power station. ITER represents the next major step in the advancement of fusion science and technology, and it is the key element in the strategy to reach the

[9] The LHC project cost does not include permanent laboratory staff and other laboratory resources used to construct the LHC.

evolutionary demonstration electricity-generating power plant (DEMO) in a single experimental step. The United States, China, the EU, Japan, Korea and Russia are all part of the ITER international team. The United States plans to spend $38 million on the ITER project in 2005; the United States is expected to provide a 10% share of the total construction costs. Construction is scheduled to begin in 2006.

The DOE and the National Institutes of Health (NIH) coordinated the Human Genome Project (HGP) to identify all of the approximately 30,000 genes in human DNA and to determine the sequences of the 2.9 billion chemical base pairs that make up human DNA. At least 18 countries have established their own human genome research programs; more than 20 research centers worldwide were involved in the HGP. The U.S. share amounted to about 53% of the 2.9 billion base pairs, at a cost of $2.7 billion over the project's 15-year duration. (Pennisi 2003)

The International Nucleotide Sequence Database Collaboration, comprised of the DNA DataBank of Japan (DDBJ), the European Molecular Biology Laboratory (EMBL), and GenBank at the National Center for Biotechnology Information, allows researchers from around the world to combine their findings.

The NSF maintains a Major Research Equipment and Facilities Construction (MREFC) account, which NSF uses to acquire, construct, commission, and upgrade major research facilities and related equipment. The MREFC account currently supports the following construction projects:

- South Pole Station Modernization (SPSM) – FY 1998
- Network for Earthquakes Engineering Simulation (NEES) – FY 2000
- Atacama Large Millimeter Array/Millimeter Array (ALMA/MMA) – FY 1998
- Large Hadron Collider (LHC) – FY 1999
- IceCube Neutrino Detector – FY 2002
- EarthScope – FY 2003
- High-Performance Instrumented Airborne Platform for Environmental Research (HIAPER) – FY 2000

New projects proposed in NSF's FY 2004 budget to receive MREFC funding for FY 2004, 2005, or 2006 include the following:

- National Ecological Observatory Network (NEON) Phase I – FY 2004
- Integrated Ocean Drilling Program (IODP) – FY 2005
- Rare Symmetry Violating Processes (RSVP) – FY 2006
- Ocean Observatories Initiative (OOI) FY 2006

As the examples above indicate, international research projects can be organized with or without a central research location. Organizations like CERN combine international funding to build expensive research tools to be used at a single location, whereas projects such as the HGP use innovative communications technologies to pool discoveries made anywhere in the world. The cost of research equipment and the type of research topic determine the appropriate framework for a given collaborative program.

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Pennisi, E. 2003. Human genome: Reaching their goal early, sequencing labs celebrate. *Science* **300**:409.

Shore, B. and B. J. Cross. 2003. Management of large-scale international science projects: Politics and national culture. *Engineering Management Journal* **15**:3[?], 25-34.

National Research Council. Committee on Setting Priorities for NSF-Sponsored Large Research Facility Projects. 2004. *Setting Priorities for Large Research Facility Projects Supported by the National Science Foundation.* Washington, DC: Academy Press.

U.S. Office of Management and Budget (OMB). 1999. *Department of Energy Budget Request FY 1999*. Washington, DC: Office of Management and Budget.

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Appendix C: Information Brief on Summary of Interviews on Scientific Cooperation between the United States and Europe

Background

- International scientific collaboration is a critical dimension of scientific progress.
- To identify key issues that would form the basis of the PCAST conference, the White House Office of Science and Technology Policy (OSTP) commissioned a series of interviews with leading representatives from academia, scientific professional societies, industry and the U.S. federal government.
  - OSTP conducted a total of 14 interviews over a two-month period.
- The open-ended discussions that resulted from these interviews generated an overall picture of the most critical issues in European-U.S. scientific cooperation, namely:
  - Intellectual property
  - Cooperative research funding
  - Visas
  - The promotion of collaborations and international research excellence
- This information brief presents a summary of comments together with links to related key readings.

Introduction

"There is no national science, just as there is no national multiplication table; what is national is no longer science." - Anton Chekhov

In June 2004, the President's Council of Advisors on Science and Technology (PCAST) began planning a conference on ways to enhance scientific cooperation between the United States and Europe. The purpose of the conference was to explore contemporary issues related to transatlantic cooperation at the individual, academic, corporate and national levels.

To identify key issues that would form the basis of discussions at the conference, the Council commissioned a set of interviews conducted by the Science and Technology Policy Institute (STPI) at the Institute for Defense Analyses. STPI, in coordination with members the Office of Science and Technology Policy and PCAST, conducted 14 interviews over a two-month period with leading representatives of academia, scientific professional societies, industry, and the Federal Government.

The interviewees were selected using suggestions from PCAST staff as well as a "snowball" approach; that is, soliciting suggestions for additional interviewees from stakeholders with expert knowledge who, in turn, suggested other interviewees, and so on. This approach led to the identification of interviewees who collectively represented the stakeholder communities. (See Appendix C-1 for a complete list of interviewees.)

The interviews took the form of open-ended discussions that were designed to provide PCAST with an overall picture of the most critical issues in European-U.S. scientific cooperation. While recent journal articles and media coverage suggest certain priority areas (e.g., visas, scientific openness, and security), STPI sought to identify a broader range of issues and barriers related to academic, corporate, and government policies. (See Appendix C-2 for a copy of the interview protocol.)

This document summarizes the observations gathered through this interview process. Also included are links to key documents at various points throughout the brief related to many of the topics raised during the course of the interviews.

Interviewee Observations

Four major themes emerged during the interviews, each of which is treated in detail below:

1. Intellectual property
2. Funding cooperative research
3. Visas
4. Promoting collaborations and international research excellence

Intellectual Property

Many industry representatives cited intellectual property as a critical issue; fewer members of academia and scientific professional societies identified this as one of their key issues. Industry members noted that inconsistencies in patent laws between the United States and Europe discourage transatlantic cooperation. For example, in the United States only the inventor may claim a patent for an invention (called the "first-to-invent rule"). In Europe, on the other hand, whoever files the patent first is assumed to be the inventor (called the "first-to-file rule"). Representatives from one European company noted their concern that these legal differences could lead to the loss of intellectual property rights resulting from collaborative projects with U.S. companies.

Industry and non-industry representatives both raised the issue of the transferal of intellectual property rights. One interviewee cited intellectual property clauses in government-government agreements that give the United States far-reaching control, which may discourage cooperation. Another interviewee explained that many companies automatically transfer intellectual property rights from operating entities to a central body. For example, if a company research lab is granted a patent, the patent becomes the property of the corporation and not the research lab or any individual or group within the lab. Current European Union (EU) policy requires non-EU companies engaged in cooperative research sponsored by the EU to notify the European Commission 60 days in advance if the company wishes to transfer intellectual property outside of the EU, to allow the Commission time to confirm or deny the transfer. This conflict between company policies and EU policies has created problems for U.S. companies and serves as a disincentive to participate in these cooperative agreements.

Key documents:

Guntersdorfer, M. 2003. Software patent law: United States and Europe compared. *Duke Technology and Law Review* **6**. http://www.law.duke.edu/journals/dltr/articles/2003dltr0006.html

Kaminski, M.D. 2001. Patent harmonization: International efforts are gradually unifying the world's patent laws. *Modern Drug Discovery* **4**:1, 36-37.
http://pubs.acs.org/subscribe/journals/mdd/v04/i01/html/patents.html

Funding Cooperative Research

Interviewees from the academic community and from scientific professional societies expressed concern about the funding of collaborative scientific research, especially with regard to additional incentives for European participation in United States-led research. One interviewee stated that collaborative research is an active instrument of foreign policy between Europe and the United States and that a systematic effort should be made to sponsor and fund such research.

Many interviewees pointed to the lack of financial incentives as a primary reason that European researchers do not collaborate to a greater extent with their colleagues in the United States. Because many European countries have national funding systems, and because European policies are making more funding available within the EU, these sources are more attractive than what the United States has to offer.

Key documents:

Commission of the European Countries. 2004. Science and technology, the key to Europe's future: Guidelines for future European Union policy to support research. (Brussels: the Commission).
http://europa.eu.int/comm/research/future/pdf/com-2004-353_en.pdf

European Commission. 2002. The sixth framework programme in brief. Brochure (December 2002).
http://europa.eu.int/comm/research/fp6/pdf/fp6-in-brief_en.pdf

Cordis. 2005. Sixth framework programme instruments. Website.
http://www.cordis.lu/fp6/instruments.htm (Accessed September 5, 2005)

Visas

The most frequently cited issues related to visas. Several representatives from the academic community and scientific professional societies consider visas as one of the most important—if not the most important—issue to address; industry representatives tended to consider visas less of an issue, though still an important one. The overall concern voiced by members of the academic community and scientific professional societies was the creation of a transparent, streamlined process for moving students and researchers between the United States and Europe. Specific issues included delays in issuing visas as a result of repetitive security checks, as well as perceived inefficiencies in the visa renewal processes.

Industry representatives stated that, typically, they conduct research and development (R&D) at a single site, or through geographically distributed teams that collaborate through virtual networks. Despite these operational models, private companies that move employees between Europe and the United States have specific concerns regarding visas. One industry executive cited a current example of a researcher working in the United States who had to return to Europe for family reasons; the researcher cannot now gain re-entry into the United States without undergoing a lengthy readmission process. Corporate leaders believe that they should be able to move their human capital the same way they move their products so as to compete most effectively in a global economy.

An industry representative suggested that companies be given "fast track" approval to move individuals among countries using a screening process. In other words, a company would undergo a review process, obtain approval, and subsequently have autonomy to move researchers in and out of countries for business purposes.

Key documents:

American Association for the Advancement of Science. 2004. Leading science, higher-education and engineering groups urge six improvements to U.S. visa-processing quagmire." Press release. http://www.aaas.org/news/releases/2004/0512visa.shtml

Marburger, J. 2003. Statement before the Science and Technology Policy Colloquium, American Association for the Advancement of Science, April 10, Washington, DC. http://www.ostp.gov/html/jhmAAASvisas.pdf

Morton, C.C. 2004. Visa woes threaten conduct of science. *Focus: News From Harvard Medical, Dental, and Public Health Schools.* http://focus.hms.harvard.edu/2004/April2_2004/special_report.html

Neuschatz, M. and P. Mulvey. 2003. Physics students from abroad in the post-9/11 era. AIP Publication R-437. Report. http://www.aip.org/statistics/trends/reports/international.pdf

U.S. Congress. House. Committee on Government Reform. Statement of C. Stewart Verdery, Jr. 108th Cong., 2nd sess., September 9, 2004. http://reform.house.gov/UploadedFiles/DHS%20-%20Verdery%20Testimony.pdf

Promoting Collaborations and International Research Excellence

Interviewees from all sectors expressed interest in facilitating cooperation and promoting research excellence on both sides of the Atlantic. Interviewees generally agreed that the European Union is concerned that Europe is losing its scientists to the United States and not, in turn, attracting U.S. scientists to Europe. One interviewee stated that, "global experience is imperative in the business world, and it should be presented as similar in the scientific world. We need a framework that will make internationalization more attractive."

Interviewees from academia and scientific professional societies cited the importance of facilitating networks between researchers, and the need for updated information on the location of research in various countries. One interviewee stated that in many cases, especially at the post-doctoral fellowship level, individuals do not go overseas because they do not know where research in their field is being done; another interviewee stated that much of the international collaboration being conducted today is the result of chance meetings at conferences.

Several interviewees were aware of the EU's efforts to create an environment of mobility within Europe, and to encourage international researchers to come to the EU. For example, the European Research Agency Mobility of Researchers (ERA-MORE) program is a group of local offices that help foreign researchers acclimate upon their arrival. Interviewees were not aware of a similar program within the United States, or of special efforts by U.S. researchers to take advantage of ERA-MORE.

Key documents:

Commission of the European Communities. 2001. A mobility strategy for the European research area. Report. http://europa.eu.int/eracareers/docs/Com_2001_331_en.pdf

Association of International Educators (NAFSA). Strategic Task Force on International Student Access. 2003. In America's interest: Welcoming international students. http://www.nafsa.org/content/PublicPolicy/stf/InAmericasInterestWelcomingInternationalStudents.pdf

National Science Foundation (NSF). National Science Board. 2004. Higher Education in Science and Engineering: International S&E higher education. In Science and engineering indicators 2004. Website. http://www.nsf.gov/statistics/seind04/c2/c2s5.htm (Accessed September 5, 2005)

Wulf, W. Internationalization of the technical workforce and transatlantic cooperation in R&D. In Board on Science, Technology, and Economic Policy. 1999. *New Vistas in Transatlantic Science and Technology Cooperation* (Washington, DC: The National Academies Press). http://books.nap.edu/books/0309061970/html/88.html

Additional Interviewee Observations

In addition to the four major themes described above, several interviewees raised several other issues of concern, ranging from scientific openness and security to export controls. Interviewee observations related to each of these additional issues is discussed in detail below.

EU-U.S. Science and Technology Agreement

The EU-U.S. Science and Technology Agreement recently expired and is in the process of being renewed. Several interviewees emphasized the importance of this agreement for international collaboration and supported its continued existence.

Key document:

Commission of the European Community. 1998 Agreement for scientific and technological cooperation between the European Community and the government of the United States of America. *Official Journal* L **284**, 37-44.
http://europa.eu.int/smartapi/cgi/sga_doc?smartapi!celexapi!prod!CELEXnumdoc&lg=EN&numdoc=21998A1022(01)&model=guichett

The European Union versus EU Member States: Current and Future European Science Mechanisms and Funding

Members of the academic community and scientific professional societies expressed interest in learning more about ways to cooperate with the EU and its member states. Interviewees expressed uncertainty over whether the member states want to be viewed individually or collectively, and over the ways that EU states would prefer to engage in cooperative research with the United States.

Interviewees from academia discussed the issue of mechanisms and funding, and focused on how the EU funds scientific research. Not all countries within the EU have national funding systems for sponsoring research, and many countries need to invest in building and rebuilding scientific infrastructures. Investments in the Sixth Framework Programme (FP6) are being used to improve laboratories and equipment; furthermore, new mechanisms such as the Centers of Excellence approach are emerging. These efforts will continue and expand in the Seventh Framework Programme (FP7) in 2007, which will impact opportunities and incentives for cooperation with the United States

Key documents:

Cordis. 2005. Sixth framework programme instruments. Website.
http://www.cordis.lu/fp6/instruments.htm (Accessed September 5, 2005)

Commission of the European Communities. 2004. Science and technology, the key to Europe's future: Guidelines for future European Union policy to support research. Report.
http://europa.eu.int/comm/research/future/pdf/com-2004-353_en.pdf

Regulations and Standards Related to Scientific Openness and Security

Three interviewees—two company executives and a member of a scientific professional society—said that legislative inconsistencies between the EU and the United States acted as barriers to the effective conduct of business. They cited as specific examples policies related to genetically modified crops and stem cell research. Company executives also pointed to the need for consistent standards to allow companies to bring products into a global market, rather than developing technologies for each continent or country individually. Inconsistent standards are far more costly, and are particularly damaging to smaller businesses. Global standards—especially for software and the environment – are therefore in the best interest of all parties. Three interviewees specifically mentioned the need to create a system for classifying research that facilitated the dissemination of research results while also addressing security concerns.

Key documents:

Gast, A. [n.d.]. The impact of restricting information access on science and technology. Report. http://www.aau.edu/research/Gast.pdf

Gray, P. 2003. Security versus openness: The case of universities. *Issues in Science and Technology* **19**:4. http://www.issues.org/issues/19.4/gray.html

Hamre, J. 2002. Science and security at risk. *Issues in Science and Technology* **18**:4. http://www.issues.org/issues/18.4/hamre.htm

Regulations and Standards Related to Export

One European industry representative interviewed cited the lack of clarity with certain export control policies in the United States, particularly the International Traffic in Arms Regulations (ITAR) and the Export Administration Regulations (EAR). The complexity of these regulations, coupled with the different export controls applied by the United States and Europe, has created confusion that causes hesitation among European companies to collaborate with their U.S. counterparts.

Key documents:

U.S. Department of Commerce. Bureau of Industry and Security. 2005. Introduction to Commerce Department export controls. Website. http://www.bxa.doc.gov/licensing/exportingbasics.htm (Accessed September 5, 2005)

U.S. Department of State. Directorate of Defense Trade Controls. 2005. Defense trade controls: Reference library. Website. http://www.pmdtc.org/reference.htm (Accessed September 5, 2005)

Issues Regarding Facilities Locations

Interviewees from academia and scientific professional societies expressed concern over issues that have recently arisen regarding the location of facilities, and particularly concern over the process used to determine the International Thermonuclear Experimental Reactor (ITER) site. Such disagreements serve as disincentives for collaboration.

Key documents

International Thermonuclear Experimental Reactor (ITER). 2005. Website. http://www.iter.org/ (Accessed September 5, 2005)

The Economist. "Bouillabaisse sushi." February 5, 2004. Available online at: http://www.economist.com/science/displayStory.cfm?story_id=2404587

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Appendix C-1: List of Individuals Interviewed

Name	Affiliation*	Title	Interview Date(s)
David Schindel	National Science Foundation	Director, European Office	July 7, 2004 July 12, 2004
Alan Leshner	American Association for the Advancement of Science/*Science*	CEO/ Executive Publisher	July 15, 2004
Charles Vest	MIT	President	July 19, 2004
Bruce Alberts	National Academy of Sciences	President	July 29, 2004
Michael Maibach	European-American Business Council	President and CEO	July 29, 2004
Norm Neureiter	American Association for the Advancement of Science	Director, Center for Science, Technology and Security Policy	July 29, 2004
David McQueeney	IBM	Vice President, Technology and Strategy, US Federal	July 30, 2004
Gary Koehler	Lyondell	Director of Chemicals Research and Development	August 11, 2004
Douglas Gregory	IBM	Vice President, Governmental Programs, Europe, Middle East, Africa	August 11, 2004
Guy Rini	Mack Trucks, Inc	Director, Advanced Propulsion Systems	August 12, 2004
Steve Hardesty	Department of State	US Science Counselor, US Mission to the EU, Brussels	August 19, 2004
Francisco Escarti	Boeing	Vice President, Business Development - Europe	September 1, 2004
Valerie Manning	European Aeronautic Defence and Space Company (EADS)	Director, Strategy & Analysis, North America	September 2, 2004
Bernard Boime	European Aeronautic Defence and Space Company (EADS)	Head of Information Technology, Corporate Research Center	
Yann Barbaux	European Aeronautic Defence and Space Company (EADS)	Vice President and Head of Operations, Corporate Research Center, France	

*Affiliation at time of the interview.

Appendix C-2: Interview Protocol[10]

The Presidential Council of Advisors on Science and Technology (PCAST) is convening an agenda-setting workshop in October on barriers to conducting collaborative EU-U.S. scientific research. Abt Associates is working with the Science and Technology Policy Institute at the Institute for Defense Analyses to assist PCAST in arranging this conference and setting its agenda.

We are conducting interviews with selected individuals to identify a set of key barriers to conducting EU-U.S. collaborative research, around which the presentations and discussions at the conference can be focused.

Dimensions for assessing potential barriers to collaboration

We have identified a set of dimensions for assessing potential barriers to collaboration.
Some examples are:

- *Mechanisms*: barriers may differ for "big science" vs. centers of excellence or vs. graduate student exchanges among universities
- *Countries within the EU*: barriers to scientific research may differ substantially among member countries.
- *Field of research*: barriers to research may differ in such disciplines as astronomy vs. ecology, or even more in such disciplines as physical sciences vs. earth sciences.
- *National perspectives*: U.S. perspectives and EU member states' perspectives on barriers may differ substantially.
- *Organizational level*: government to government, institution to institution, and researcher to researcher.

We would like your input on the following topics:

1. Major barriers to conducting collaborative scientific research between the member states of the EU and the United States
2. Policies PCAST might consider that would help to overcome these barriers
3. Dimensions in addition to those above do you see as potentially influencing these barriers
4. The names of other individuals from whom to seek input as we plan this conference
5. Potential speakers/attendees
6. What you would suggest as key "products" of the conference

[10] Please note that this document was used as a basis for a conversation. Depending on responses from interviewees and their areas of knowledge and interest, interviews often focused more on certain topics than others and/or deviated from those listed here.

Appendix D: List of National and International Organizations and Agencies Cited

National Organizations and Agencies (including academic and private industry facilities)

Barcelona European Council

Centre National d'Etudes Spatiales

DaimlerChrysler AG

Deutsche Elektronen-Synochrotron (DESY)

Deutsche Forschungsgemeinschaft (DFG)

Ford Motor Company

Gemini Observatory

General Motors

Georgetown University

Georgia Institute of Technology, Belgium

Haldor Topsoe A/S
- Research & Development Division

Howard Hughes Medical Institute

National Science Foundation

Nokia Research Centre

University of Arizona

U.S. Council for Automotive Research (USCAR)

U.S. Department of Commerce
- National Oceanographic and Atmospheric Administration

U.S. Department of Energy (DOE)

U.S. Department of Health and Human Services
- National Institutes of Health

U.S. Department of Homeland Security
- Border and Transportation Security Directorate

U.S. Executive Office of the President
- Office of Science and Technology Policy
  - President's Council of Advisors on Science and Technology (PCAST)

U.S. National Aeronautics and Space Administration (NASA)

U.S. National Science Foundation

U.S. Office of Naval Research

U.S. State Department
- Bureau of Consular Affairs

International Organizations and Agencies

Carbon Sequestration Leadership Forum

Conseil Européen pour la Recherche Nucléaire/ European Organization for Nuclear Research (CERN)

European-American Business Council

European Commission
- Research General Directorate
  - Research Training Networks Unit
  - Energy Directorate

European Industrial Research Management Association

European Network of Mobility Centers

European Research Advisory Board (EURAB)

European Space Agency (ESA)

Global Earth Observation System of Systems (GEOSS)

International Arid Lands Consortium

International Committee for Future Accelerators

International Crops Research Institute for the Semi-Arid Tropics

International Linear Collider

International Maize and Wheat Improvement Center

International Thermonuclear Experimental Reactor (ITER)

Large Hadron Collider

Particle Physics & Astronomy Research Council

Semiconductor Industry Association

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