DOCUMENTED BRIEFING

RAND

Linking Effectively: Learning Lessons from Successful Collaboration in Science and Technology

Caroline S. Wagner, Linda Staheli, Richard Silberglitt, Anny Wong, James Kadtke

DB-345-OSTP

April 2002

Prepared for White House Office of Science & Technology Policy

Science and Technology Policy Institute

The RAND documented briefing series is a mechanism for timely, easy-to-read reporting of research that has been briefed to the client and possibly to other audiences. Although documented briefings have been formally reviewed, they are not expected to be comprehensive or definitive. In many cases, they represent interim work.

REPORT DOCUMENTATION PAGE

Form Approved OMB No. 0704-0188

1. REPORT DATE (DD-MM-YYYY)
01-04-2002

2. REPORT TYPE

3. DATES COVERED (FROM - TO)
xx-xx-2002 to xx-xx-2002

4. TITLE AND SUBTITLE
Linking Effectively: Learning Lessons from Successful Collaboration in Science and Technology
Unclassified

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Wagner, Caroline S ;
Staheli, Linda ;
Silberglitt, Richard ;
Wong, Anny ;
Kadtke, James ;

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME AND ADDRESS
RAND
Science and Technology Division
1700 Main Street, PO BOX 2138
Santa Monica, CA90407-2138

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME AND ADDRESS
White House Office of Science & Technology Policy
,

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
APUBLIC RELEASE
,

13. SUPPLEMENTARY NOTES

14. ABSTRACT
See report

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:

17. LIMITATION OF ABSTRACT
Same as Report (SAR)

18. NUMBER OF PAGES
59

19. NAME OF RESPONSIBLE PERSON
http://www.rand.org/publications/DB/DB345/DB345.p
rbezwada@dtic.mil

a. REPORT	b. ABSTRACT	c. THIS PAGE
Unclassified	Unclassified	Unclassified

19b. TELEPHONE NUMBER
International Area Code
Area Code Telephone Number
-
DSN
427-9001

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39.18

PREFACE

This documented briefing describes the results of an inquiry conducted by RAND's Science & Technology Policy Institute for the Office of Science and Technology Policy (OSTP) of the Executive Office of the President of the United States. OSTP asked RAND to provide insights into improving the efficiency and effectiveness of government-sponsored international collaboration in science and technology. This document can be used as the basis for a workshop addressing the questions of creating effective international linkages in science and technology.

This project had three goals: (1) to improve understanding of the dynamics of international collaboration in science and technology, (2) to provide tools for policymakers seeking to improve the effectiveness and efficiency of collaboration, and (3) to coordinate with analysts conducting similar studies in different countries. Four case studies conducted for the RAND effort provide the research from which we draw lessons learned about linking effectively. Policymakers faced with decisions about participation and resource commitment may find helpful ideas about forming and supporting collaboration.

The motivation and methodology for this study derives from a broad set of consultations among analysts in a number of countries, including Canada, Japan, Korea, and countries of the European Union (EU). Each of these countries and the EU is fielding a team of researchers conducting a parallel study on the same four cases. Once all the different country studies are complete, a workshop will be conducted and a final coordinated report will be compiled to examine collaboration from a number of different national perspectives. It is hoped that the lessons learned from the individual country studies, and those derived from comparing the studies, will provide government policymakers with a tool kit of policy options to help in thinking more strategically, creatively, and efficiently about advancing science and technology.

This project has the advantage of both studying collaboration as well as *being* a collaboration. We hope to be able to learn as much from our own efforts at conducting an international collaborative project as we do from studying successful collaborations. These lessons will be shared and enumerated at a workshop in 2003.

The examination of successful collaboration cases from the United States' perspective is complete with the publication of this documented briefing. However, the view from the United States is only one small part of a larger picture. Without understanding how other countries view the same programs, how well these organizational structures worked for other countries, and what issues and problems they faced, this document would only be of limited use. We welcome feedback from any reader or reviewer. Nevertheless, this is an interim product—we await the results from other analysts in other countries before we can tell the full story of lessons learned from participation in international scientific and technical collaborations.

Created by the U.S. Congress in 1991 as the Critical Technologies Institute, it was renamed the Science and Technology Policy Institute in 1998. The Institute is a federally funded research and development center sponsored by the National Science Foundation and managed by RAND. The Institute's mission is to help improve public policy by conducting objective, independent research and analysis on policy issues that involve science and technology. To this end, the Institute

- supports OSTP and other executive branch agencies, offices, and councils

- helps science and technology policymakers understand the likely consequences of their decisions and choose among alternative policies
- improves understanding in both the public and private sectors of the ways in which science and technology can better serve national objectives.

In carrying out its mission, the Institute consults broadly with representatives from private industry, institutions of higher education, and other nonprofit institutions.

Inquiries regarding the Science and Technology Policy Institute or this document may be directed to:

Helga Rippen
Director, Science and Technology Policy Institute
RAND
1200 South Hayes Street
Arlington, Virginia 22202
Phone: 703-413-1100, ext. 5574
Web: www.rand.org/scitech/stpi
Email: stpi@rand.org

SUMMARY

This briefing seeks to answer three questions: (1) Why study the subject of formal, government-sponsored collaboration? (2) What did we learn from the four case studies that gave an in-depth look at the U.S. experience in sponsoring and participating in these programs? and (3) Can these programs be evaluated and are they worth the extra effort that is required to initiate and sponsor them?

This briefing is organized to answer these questions, as well as to raise points of discussion and debate among those interested in this subject. It is presented in a format that draws lessons from the case studies and then presents key questions that emerged from the cases that can serve as a guide to others seeking to formulate similar collaborative programs.

The first section discusses the growing role that international collaboration is playing in science and technology (S&T). Here we also discuss the case study methodology used for this study. The second section presents a framework of "lessons learned" that emerged from our examination of cases of successful collaboration. RAND created this framework as a tool to help policymakers create effective linkages in the future. The third section discusses, from the U.S. perspective, what people reported to us as some of the benefits of participating in international collaborations.

The briefing has two components: a set of slides and a written accompaniment. The two parts are designed to be used together and read as a report, and it can also serve as the basis for a workshop. Agency officials seeking to explore the creation of formal international collaborations may wish

to use this briefing to generate discussion and comment among colleagues and potential collaborators.

It is important to set out the context of some common terms used in this report:

- S&T refers to the many different investments made by the governments in basic research, in applied research, in development of equipment and standards, and in data collection and analysis needed both to increase knowledge about the natural world and to help the government in its various missions.
- Research and development (R&D) is a subset of S&T activities. The term refers to programs and projects budgeted as “research and development” by federal agencies. These are activities that seek to apply the scientific method to specific experimental questions identified by government agencies as important and validated by scientific peers as worthwhile.
- Curiosity-driven research is the set of S&T activities that are proposed by scientists and conducted, usually as basic research, because the subject is not well understood and where the application of the scientific method of observation and experimentation may add to the stock of knowledge.
- Mission-oriented research is the set of S&T activities that are defined by government agency officials who commission or conduct research (usually applied research or development) that will advance knowledge needed for an agency to carry out its mission.
- Policy-oriented research is the set of S&T activities that are defined by government officials or elected representatives to reach a policy-oriented goal using S&T as a tool.
- Cooperation refers to all the programs, projects, and support activities sponsored by the U.S. government with foreign entities that have a scientific or technical component. It can include joint R&D, technical

assistance, technology transfer, standards development, and other types of joint activities.

- Collaboration refers to the specific scientific activities (research and observation, experimentation, data collection, publication) conducted by scientists working together on a common research project.

- “Champion” is a term applied to a scientist who has taken on the task of promoting to interested parties—legislators, other scientists, the public—the value of government funding for a specific program or course of research.

ACKNOWLEDGMENTS

The project team would like to thank our international collaborators who worked closely with us to conceptualize this study, design the methodology, and select the case studies. In particular, Professor Josephine Ann Stein (United Kingdom) was instrumental in crafting the initial idea and moving the project forward. Early on in the process, Professor Yuko Fujigaki (Japan) was helpful in conceptualizing and identifying the case studies. Dr. Paul Dufour (Canada) of Industry Canada also provided input and enthusiastic support in the initial design stages of the study.

As the study developed and took shape, additional participants have joined and provided considerable intellectual support to the project. Among these are Dr. Yoshiko Okubo (France), Professor Ryo Hirasawa (Japan), Professor John DelaMothe (Canada), Dr. SungChul Chung (Korea), and Dr. MyJin Lee (Korea). Recently, Dr. Bernard Kahane (France) has also taken an interest in the project. RAND colleague Scott Hassell also provided valuable assistance.

We wish to thank our sponsors at the White House Office of Science and Technology Policy who initially requested and helped guide this study, including Kerri-Ann Jones, Gerald Hane, Deanna Behring, and Amy Flatten. We would also like to thank members of the Global Science Forum, a committee of the Organisation for Economic Cooperation and Development, who have continued to express interest in and encouragement of this study.

Finally, the authors gratefully acknowledge the interest in this project and the willingness to be interviewed of the following individuals, who generously provided the benefit of their experience, expertise and insights, without which this study could not have been successfully conducted. These include, but are not limited to, Charles Anderson, Wendy Baldwin, Roger Barry, Rosina

Bierbaum, Mina Bissell, Kenneth Broad, Lou Brown, Robert Cattoi, Mary Clutter, Francis Collins, Robert Corell, Richard Donaldson, John Dutton, Dave Easterling, Irene Eckstrand, Robert Falstad, Elbert Friday, Ed Frieman, Gerald Graves, Phyllis Genther-Yoshida, Mark Guyer, Paul Huray, Ursula Hurtenbach, Elke Jordan, James Jordan, Danuta Krotoski, Tom Knutson, Yoshiki Kurihara, Rachel Levinson, Eric Meslin, David Mitchell, Michael Morgan, William Morin, Michael Parker, Ari Patrinos, Jonathan Pershing, Marina Picciotto, Henry Pollack, Andrew Rothrock, Yoshiyuki Sakaki, Takashi Shimazu, David Slessinger, Cheryl Clark Stoll, John Sulston, Bob Watson, Robert Waterston, Jean Weissenbach, Joan Wellington, Tortsen Wiesel, Susan Wickwire, Deborah Wince-Smith, and Huanming (Henry) Yang.

The statements and conclusions contained in this report are the sole responsibility of the authors and should not be attributed to the Office of Science and Technology Policy, the National Science Foundation, or to any of the individuals whom we interviewed or their organizations.

ACRONYMS

EU	European Union
HFSP	Human Frontier Science Program
HGP	Human Genome Project
IMS	Intelligent Manufacturing Systems
IPCC	Intergovernmental Panel on Climate Change
OSTP	Office of Science and Technology Policy
R&D	Research and development
S&T	Science and technology

This Briefing Draws Larger Lessons from Four Programs

Science & Technology Policy Institute

Why Study this Subject?

I. Formal Collaboration is Growing

- Purpose for and methodology of this study

What did We Learn by Studying Collaboration?

II. Dynamic Research Needs Effective Linkages

- Six stages characterize these activities
- Key questions are identified at each stage

Are these Programs Worth the Effort?

III. New Ways are Needed to Measure Benefits

2 RAND

I. A GROWING ROLE FOR INTERNATIONAL COOPERATION IN SCIENCE AND TECHNOLOGY

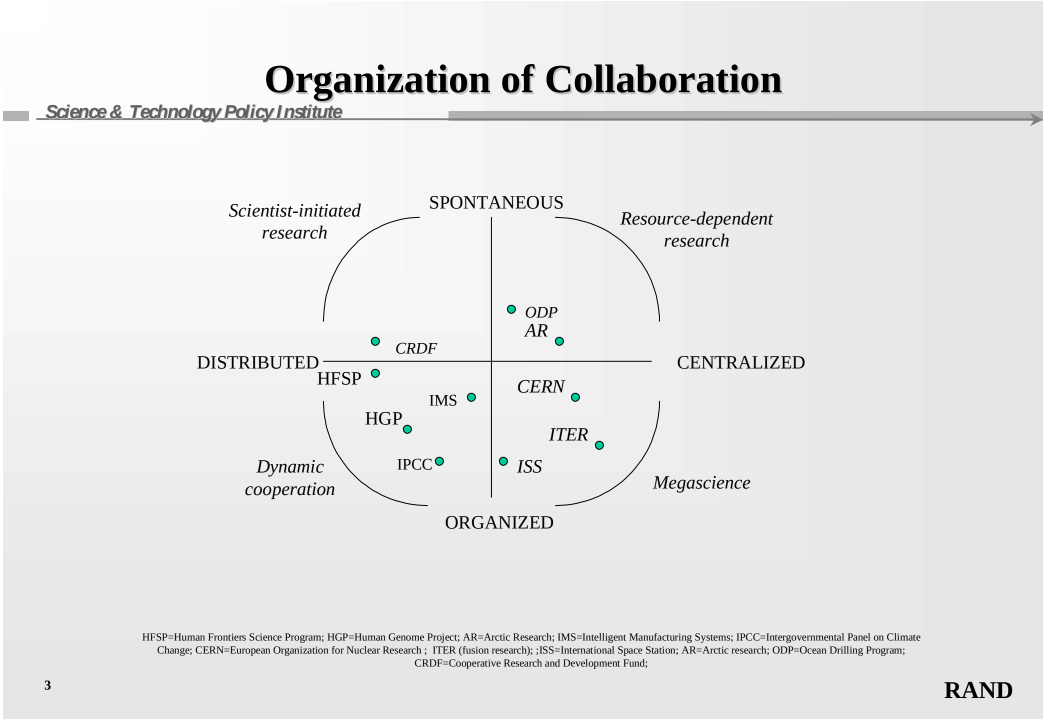
International linkages in science and technology are increasing and the uses of science within society are growing more complex. Co-authorships of scientific articles show a significant increase in international linkages over the past 20 years. (NSB 2000) The applications to which science is put to address global problems such as the climate, food supply, health, and economic growth are more numerous and of interest to more and more countries. The growing number of countries with scientific capacity has expanded the pool of potential partners. (Wagner et al., 2001)

The methods used by scientists to create new knowledge are also changing. The frequency and ease of travel increases the dynamism of knowledge sharing. This has led to more robust networks of scientists. The increasing ubiquity of information and communications technologies means that scientists can share information in real time. This had led to the growth of distributed research in a range of activities, some are called "co-laboratories" or "virtual laboratories," and others are simply collaborations—where practitioners conduct parallel research in their home labs and share results in real time. Gibbons et al.(1994) have suggested that many areas of research are growing more multidisciplinary and team oriented.

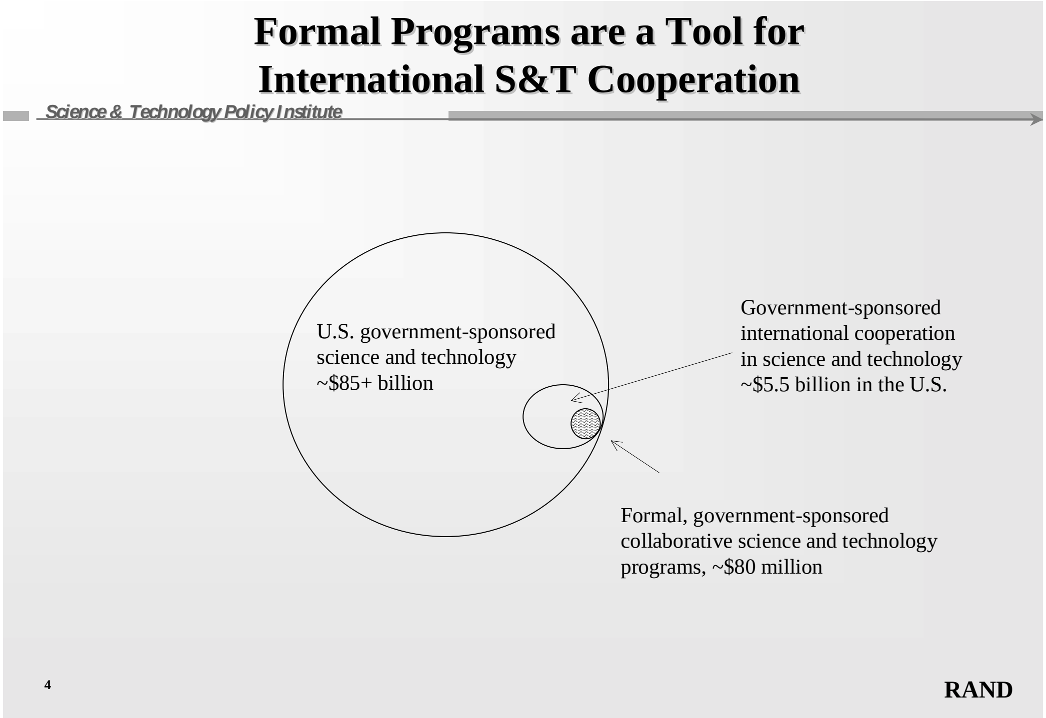
In the face of these changes, policymakers are faced with complex choices about how best to support and participate in global science and technology. At intergovernmental meetings on science and technology, proposals for joint research are often on the agenda. These are not unwelcome: When scientific goals are sound, governments can use these programs to enhance the productivity of national science, as well as to create good will and gain political capital.

Governmental participation and support of international science and technology (S&T) collaboration requires decisions to be made at many different points and on a number of levels. This project examined a subset of international scientific collaborations: the formal government programs that operate in a *distributed* way, involving scientists from a number of different countries as well as across different institutional sectors and disciplines.

The briefing covers three areas: 1) the dynamics of international collaboration as a tool for governments; 2) findings from four case studies we conducted on distributed international collaboration; and 3) considerations of how to measure the benefits of these activities, at least from the point of view of U.S. policymakers supporting this work.



Why did we focus on this particular subject? To answer that, it helps to put international S&T cooperation in context and describe its dynamics. The figure on this slide shows two axes that can be counterposed to describe different organizational forms of collaboration. One axis runs from spontaneous (“bottom-up”) research deriving from the interests of scientists, to highly organized research defined by a funding party. These two axes form four quadrants where collaborative research can be characterised. Activities on the left side of the figure might be described as “dynamic” in that collaboration requires active learning and sharing of tasks, and of information among researchers who are often geographically dispersed. Activities on the right might be described as material/institutional research in that collaboration relies on a shared resource or common research location. Megascience projects could be placed in the bottom right quadrant: organized and centralized. The projects that we examined could be placed in the bottom-left quadrant: organized and distributed research activities. The differences in organization, location of research, and dynamism of the communication, require new ways of managing that differ from the practices that policymakers might use for megascience or for spontaneous research at the project level.



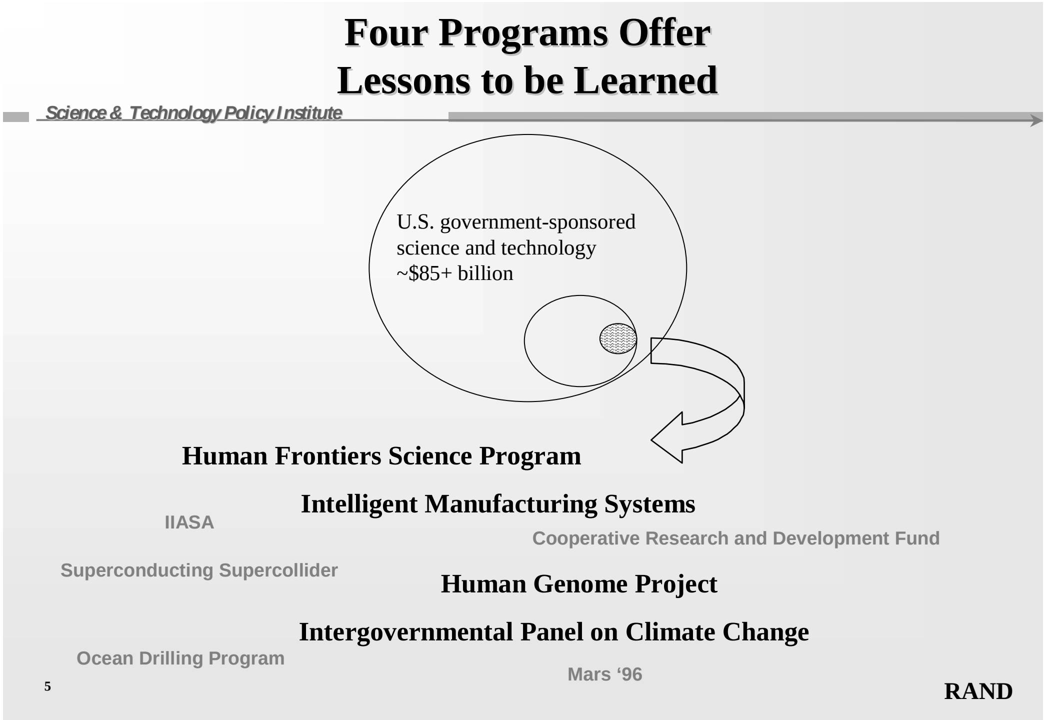
Formal international collaboration accounts for about 6 percent of the more than $80 billion the U.S. government spends on S&T. This set of activities can be characterized in several ways:

- The largest class of activities is independent research projects involving scientist-to-scientist linkages for those working on curiosity-driven projects. These projects could be placed in the top half of the figure on slide 3.

- A second, but smaller, set of activities is the formal, subject-specific programs from which the cases examined in this study are drawn. These are the organized-distributed projects described on slide 3.

- A related set of formal, equipment-based or laboratory-based programs are often referred to as “megascience” programs. These are the organized-centralized activities in the bottom right quadrant of slide 3.

Each of these classes of activities has different motivations for government spending, and each requires a different approach to management, assessment and evaluation.



Even if we agree that formal, distributed research constitutes an emerging class of activities, why focus on them specifically? Distributed research has features that make them an altogether new form of collaboration. Unlike scientist-to-scientist collaboration ("bottom-up" research) or megascience, these distributed research programs are dynamic—they use the global information infrastructure and they are team-oriented, task-sharing, and often cross-disciplinary. Managing these programs requires a different set of skills than those required for megascience or laboratory-based science.

We examined four cases studies in the course of this project. A number of candidate projects or programs initially were considered, but four successful cases were examined in detail to identify patterns and lessons about organization. As criteria for creating an initial list of cases, we included the following factors:

- The project represented one of a range of different motivations for government participation in international cooperation (i.e., foreign policy goal; global scientific problem; enhance basic scientific research; leverage investment in S&T).

- The program's research takes place at distributed locations, not at a central location or around a piece of large scale equipment

- Government officials view the program as having been reasonably successful in reaching its organizational structure as well as in reaching scientific and policy goals.

- The program sponsorship includes at least three different countries.

We considered but rejected the idea of examining cases of international collaboration that were not entirely successful: For example, several people mentioned the Superconducting Supercollider as worthy of study. However, unsuccessful cases appeared to have unique factors contributing to the failure of the effort. In addition, unsuccessful cases often ended early in their tenure and therefore would not provide us with the information on operations and management, which was a core part of our research question.

We should note that the cases considered involved, almost exclusively, cooperation among scientifically advanced countries. In most cases, scientifically developing countries are not active participants at the level of organization and management of research. In some cases, scientists from scientifically developing countries have taken part in research projects, but this is a small percentage of the activities. For more information on effective linkages between scientifically advanced and developing countries, please see Guidelines for Research in Partnership with Developing Countries: 11 Principles.[1]

These four cases were chosen from a larger list as part of a consultative process with our international partners. Each meets the criteria described above. In addition to these cases, the project team drew upon its own experience and understanding of international collaborations, and used some of our own experiences to help develop the six stages of effective linkages detailed in the following section. Specific examples from these four cases are included in the lessons learned.

We note that this study did not set out to determine if these cases were successful in themselves, whether they turned out good science, or whether they are worth the investment. These questions are addressed in other studies. This study looked at these programs to pull out features of success so that policymakers could have a guide in hand when considering the formation of similar efforts.

Here is a brief description of each of the four cases we examined.

Human Frontier Science Program—Foreign policy–motivated collaboration. The Human Frontier Science Program (HFSP) is an international research-funding institution, supported by nine governments, to support the neurosciences and molecular biology. The program was initiated at the suggestion of, and with initial funding by, the Japanese government. HFSP provides a good example of distributed research. In addition, governments had a strong foreign policy motivation for participating in this program in an effort to build

---

1 Swiss Commission on Research Partnership with Developing Countries (KFPE), Guidelines for Research in Partnership with Developing Countries: 11 Principles. Bern, Switzerland, KFPE Secretariat, 1998.

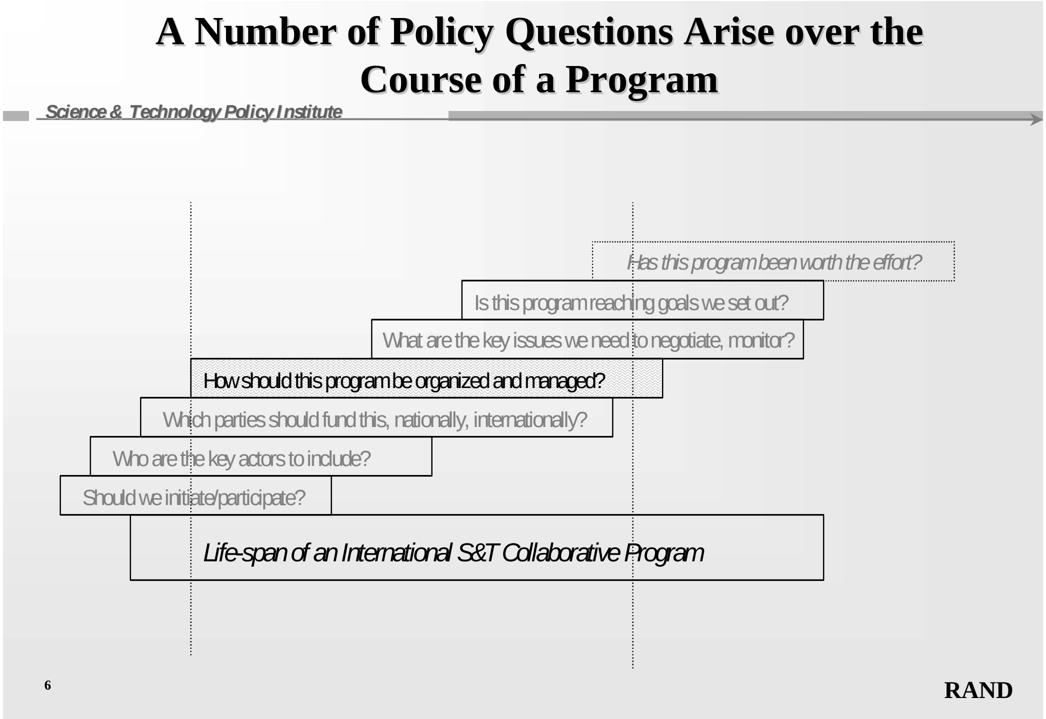
goodwill across a number of countries. This case study sheds light on how governments can jointly fund a central organization that promotes funding for basic research. The program is viewed by scientists and policymakers as having met its organization goals and exceeded its scientific goals.

Human Genome Project—Mission-directed, curiosity-driven science. The Human Genome Project (HGP), an international consortium developed to map and sequence the human genome, is an interesting case study of mission-directed research. Initiated by the United States, HGP is noteworthy as a case study in that it has maintained an informal structure that has been adaptable, inclusive, and task oriented, requiring no diplomatic-level international agreements or formal governing structure. The policy goals include leveraging knowledge in various laboratories and rapidly (almost instantaneously) sharing the results of research. Six governments provide funding and help guide this research. The program has exceeded both its organizational and research goals.

Intelligent Manufacturing Systems—commercially directed science. The Intelligent Manufacturing Systems (IMS) initiative is a coordinated program of research on pre-competitive manufacturing technology. Suggested initially by the Japanese government in 1990 and implemented in 1995, six governments and hundreds of companies now take part in the research. The case sheds light on when and how countries collaborate in sensitive technology arenas where intellectual property may be created and must be shared. Issues of competitiveness—as well as questions of intellectual property rights, access to information and facilities, talent, and technology—make this an interesting case study.

Intergovernmental Panel on Climate Change—Science addressing global problems. The Intergovernmental Panel on Climate Change

(IPCC) is a coalition of numerous scientific organizations worldwide organized to review and comment on the scientific research, research programs, and environmental policies of world nations. It is unlike the other cases in that no specific research takes place under the guise of IPCC: The program reviews research conducted anywhere in the world. However, it is a scientific collaboration, and it is a good example of nations working together to address a global problem.



Across the life span of these programs, policymakers face a number of questions (some of these important questions are illustrated in the figure above the life-span line). However, the bars partly outside the vertical lines illustrate those decisions that are largely political. It is difficult to decide how to derive generalizable lessons learned at the political level. Nevertheless, it is possible to say why existing programs were successfully operated, so this study focuses on lessons learned from the organization and management of successful collaborations.

The first step in the process involved collecting published information about the case studies. We identified policy statements, program announcements, legislation, and other program materials describing the role of governments in the international cooperative program in the four case studies. The second step involved identifying and surveying key administrative personnel and policymakers who took part in the initiation or administration of the program.

In interviews, we sought to gather information about (1) the motivation and intent of the government's participation in the program, (2) the organization and structure of the program, (3) how knowledge was created and managed, and (4) whether and what evaluation tools and methods were used.

We interviewed more than 30 scientists and policymakers, some face-to-face and others by phone. The questions we asked included:

- What was the original intent of the government's involvement in this collaboration? Was the original intent carried forth into actual planning and execution? If not, why did the original intent fail to instruct the organization of the project?

- Within the original intent, what motivating factor was more important to the government's goal: curiosity-driven science, foreign policy concerns, industrial competitiveness, a specific mission of the government, or another factor?

- Was the organization of the government's administration of this program arranged to suit national government requirements or to enhance international linkages?

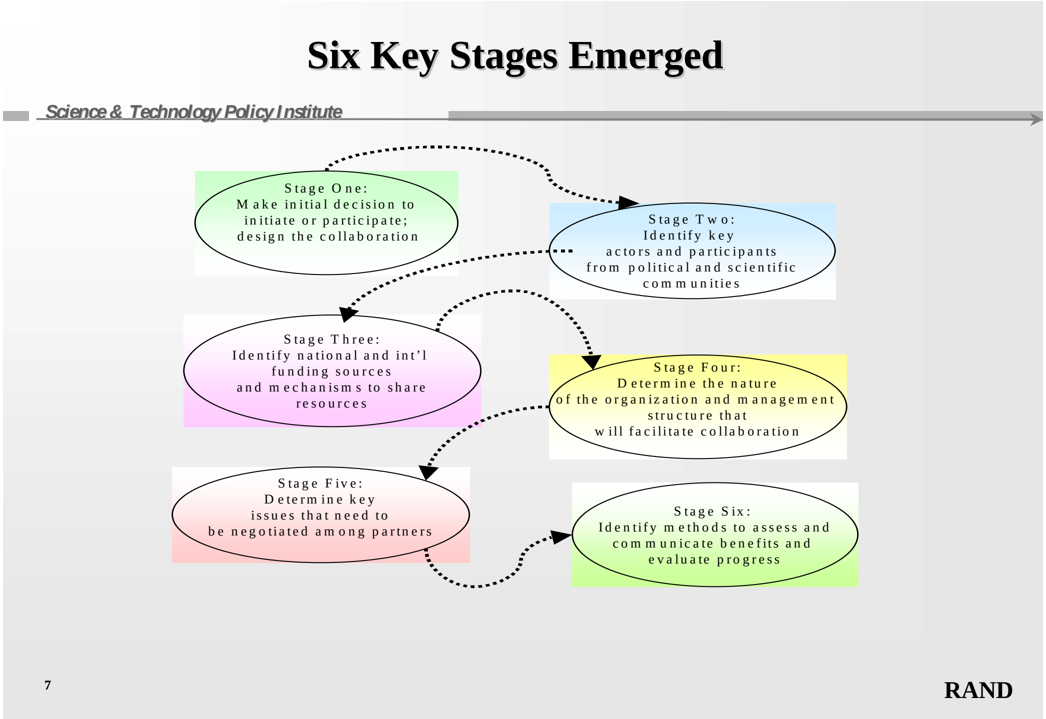
- What was successful about the government's organization and administration of this program? Why?

- What features of the government's administration and organization did not work well? Why?

- Did the program succeed in attracting excellent scientific proposals?

- How should collaborations be evaluated, especially given the difficulty of quantifying basic research outcomes?

The responses to these questions form the basis of the analysis developed in this briefing.



II. SIX KEY STAGES EMERGED

A pattern emerged from the case studies. Each of the programs presented organizers with the questions we introduced above. Once a scientific need was established as worthy of consideration, we found that the initiation, administration, and management of the four case studies could be characterized in six stages:

- an initial decision and design stage, determining whether it makes sense to create a new program on scientific grounds and whether key missions of government will be served

- an effort to identify and contact key actors from different interest groups ("stakeholders") in the political, scientific, and international communities

- a delicate stage of identifying initial and then sustainable funds and the mechanisms to share resources

- an effort to determine the organization and management structure of the actual research (or research review) process

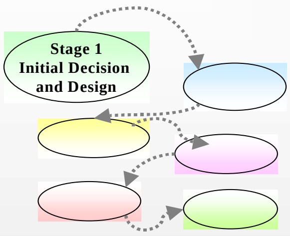
- the need to identify, negotiate, and adjudicate key issues such as sharing of intellectual property or protecting the rights of participants

- identification of the methods to evaluate progress and communicate the benefits of the activities to a range of interested stakeholders.

These stages are described in more detail in the following slides.

Political and Scientific Motivations Both Play a Role

Science & Technology Policy Institute



Governments initiate or join collaborations to:

- *create knowledge, general or specific*
- *share costs of expensive research*
- *access resources*
- *gain goodwill*
- *support specific mission*

Scientists join collaborations to:

Should we initiate/participate?

- *access scarce funding*
- *gain access to foreign labs*
- *link directly with foreign partners*
- *share information in real-time*
- *enhance creativity of research*

8

RAND

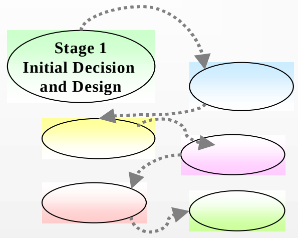
From this and other studies of international collaboration we have conducted, we find that governments and scientists are both interested in collaboration for interlocking, but often for different reasons. Governments initiate or participate in collaboration most often to meet policy goals. They seek to create knowledge, of course, but in a national scientific system as large as the United States, knowledge creation does not usually require transnational linkages. Using international collaboration to reach policy and scientific goals must carry additional benefits for governments, ones that include sharing the costs of research, as in the case of IMS's research into software that controls advanced manufacturing equipment; gaining access to resources that might not otherwise be available such as genome data; supporting a specific mission such as environmental protection; and generally creating goodwill through science.

Scientists also welcome collaborations when it helps them to effectively answer a specific research question. Even though international collaborations have higher transaction costs than local collaboration or simply working alone, scientists see a benefit to international collaboration when it funds research that might not otherwise be funded, such as some of the brain research funded by HFSP. Formal programs help open the doors to foreign laboratories that otherwise may have been difficult to access, and, at times, collaborative programs can help scientists find partners with similar research interests. Sharing information in real time is often emphasized by the formal programs, giving scientists a way to keep on top of data—this has been the case in the data-sharing polices of HGP. Scientists also report that working with foreign-trained researchers gives them new insights into how to think about science. Science is about creativity; these linkages enhance creative thinking.

During the initial phase, these programs had a number of features that helped them get off the ground. In all the cases, the organizers worked to clearly articulate a scientific and political benefit to U.S. government participation in these programs. This may not have happened initially, but as champions and organizers interacted with other decisionmakers and stakeholders, they developed and improved materials to demonstrate the usefulness of the activity. In the best cases, they persuaded key groups to become involved, and early coordination occurred across relevant U.S. government agencies. (In cases where coordination did not take place, many reported that this was, in hindsight, a mistake—coordination should have happened in the initial decision and design phase.) Policymakers also cited the need for a clear rationale for government sponsorship and national participation in the collaboration as an important feature of any decisionmaking process.

A Written Agreement is Often Needed

Science & Technology Policy Institute



Agreements can be negotiated and signed at a number of levels:

- *treaty-level agreement*
- *memorandum of understanding or agreement*
- *exchange of letters between agencies*
- *project agreement between directorate or bureau-level officials*
- *equipment-sharing agreements to facilitate cross-border exchange*

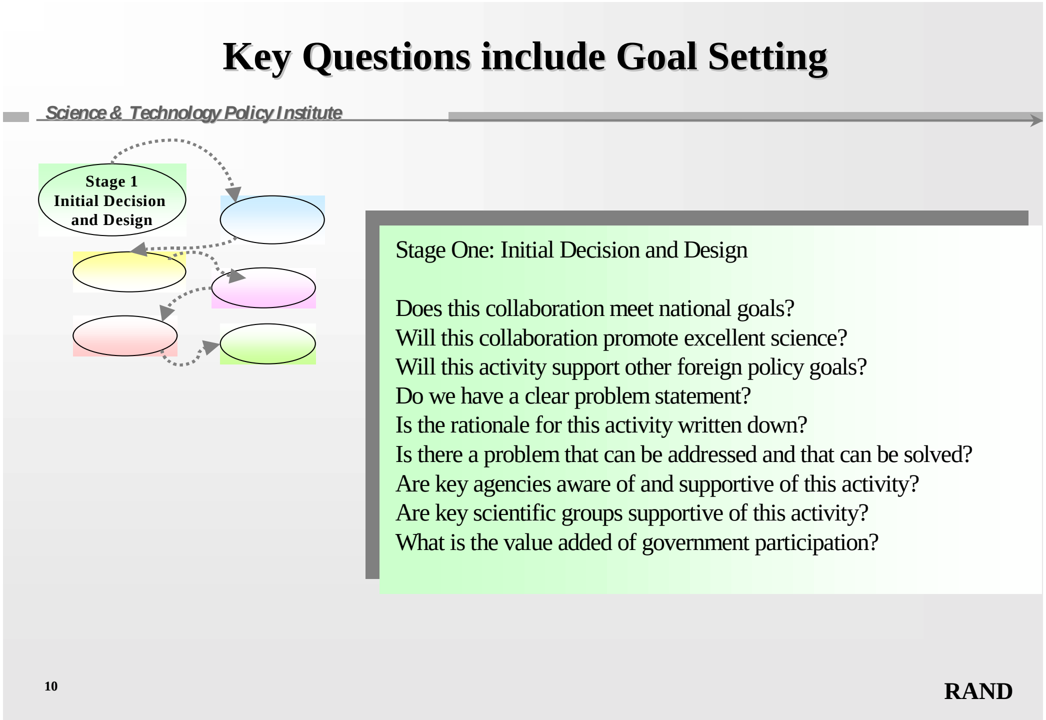
The cases we examined did not start off with high-level agreements; agreements were made at the program level

9

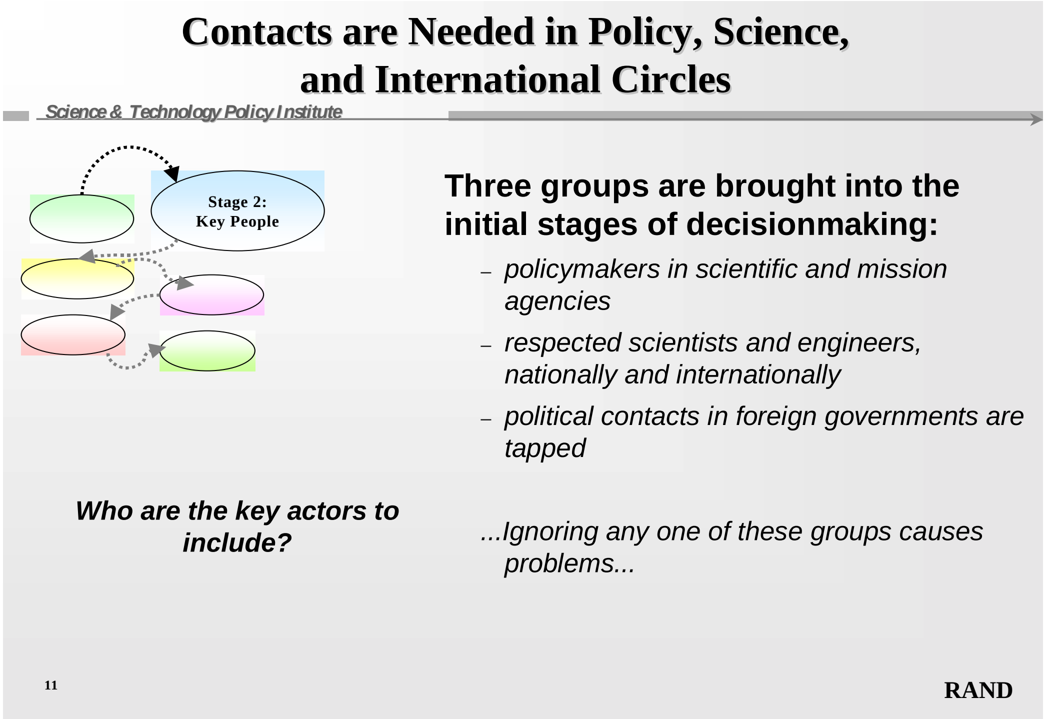
RAND

When governments get involved in organizing and managing international programs, formal agreements often establish the groundwork for interaction. There is no single template for the level at which an agreement is negotiated and none for its formality. Notably, the four cases we examined did not require or generate the need for a high-level government-to-government agreement, such as a treaty-level agreement, a bilateral S&T agreement, or even a less formal memorandum of understanding.

HFSP and IMS participants used an informal exchange of letters upon agreeing to cooperate. IPCC was conducted under existing United Nations treaties. While no formal agreements were found necessary to manage HGP, there was an agreement on data exchange where international partners agreed to formalize the conditions of data access, including release of sequence data. Participating representatives made agreements about program operations as well as guidelines for sharing funds and intellectual property, but these were largely working documents that emerged from boards of directors or scientific committees. These served as the “agreements” guiding participation and research.



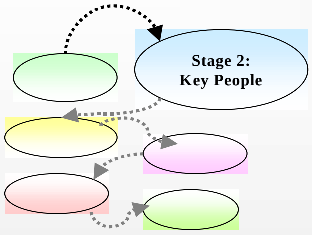
The initial decision and design phase brings us back to the first question on the list of issues facing policymakers: Should we initiate in an international collaboration or participate in one being formed? For the United States, this is a crucial question. The U.S. R&D system is huge, accounting for $230 billion annually, according to the National Science Board. Because of the sheer size of the scientific community, it is relatively easy to find a collaborator within the United States. So, for the U.S. government to consider sponsoring a collaborative project or program, there should be a compelling reason to get involved internationally rather than fund R&D within the United States. In the opinion of one policymaker, “You have to ask: Does the collaboration allow you to do things you would not do otherwise? If so, then the U.S. should definitely take part.” We found a number of reasons why the United States participated in the programs we studied, as indicated above. The motivation for participating, however, was often complex—the project needed to have scientific as well as political and, often, economic benefits. Usually, a specific case had a number of interrelated and overlapping motives that spurred U.S. government interest and willingness to participate.



Each of the case studies we examined had "champions"—individuals with credibility who promoted U.S. participation in the activity. In addition to helping get a project off the ground by convincing the scientific and policy communities that it was a worthwhile activity, champions also continued to take an interest in the program over time. As one policymaker told us: "You need committed senior people who will go to meetings and will stay with it. Trust-building is a key part of this activity." Champions promoted the project to such key stakeholder groups as the U.S. Congress and scientific societies. The champions were identified in one of two ways: (1) they were part of the initial scientific or policy team proposing the joint project, or (2) they were asked by one of the early promoters to associated their name with the project.

Key Questions include Whether a “Champion” is Involved

Science & Technology Policy Institute



Stage Two: Identifying Key Actors and Participants

Does this activity have a champion?
Are key government people on-board to aid decision-making?
Are there multiple benefits - political, scientific, commercial?
Can we effectively communicate to Congress the value of this activity?
Are respected scientists part of the planning team?
Are individuals knowledgeable about legal and institutional issues part of the planning team?
Which countries should be invited to participate?
Do other participating countries also have champions?

12 RAND

Connecting with all the stakeholders and ensuring that each group had some input were features that were identified across all the case studies as important. In several cases, a key group was ignored—an oversight that led to problems. We were told that the involvement of any and all interested groups is important.

Decisions about appropriate and interested collaborators take place, at the very least, at three different levels during the design phase: (1) within the federal government, (2) within the international S&T community, and (3) within the group of scientists and program managers who establish the initial organization.

At the federal government level, questions about appropriate actors include:

- Who within the federal government should be involved in initial design and longer-term oversight?

- Which (nationally based) scientists or engineers should be invited to discussions about U.S. interests?

- At international meetings, decisions were raised to a different level and included questions such as:

- Which countries should be involved in the design and management of these programs?

- How do we set criteria for allowing new sponsors or other new members to participate?

At the initial program design meetings, questions about actors focused on the following:

- Should private-sector researchers be involved?

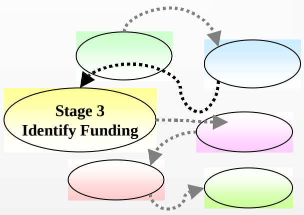
- Should the focus be on established researchers or on younger researchers?

- What types of scientists should be encouraged to apply for support or to engage in collaborative research?

- Should collaboration take place at the laboratory level (i.e., support goes to a lab and is distributed at the site) or at the scientific level (i.e., scientists receive direct support and can work at the laboratory of their choice)?

Ensuring Funding Commitments is a Delicate Step

Science & Technology Policy Institute



Which parties should fund this program, nationally, internationally?

Funding sources:

- *solely government-funded*
- *government-industry jointly funded*
- *industry-only funding*
- *international organizations*
- *combined sources of funding (including foundations, universities)*

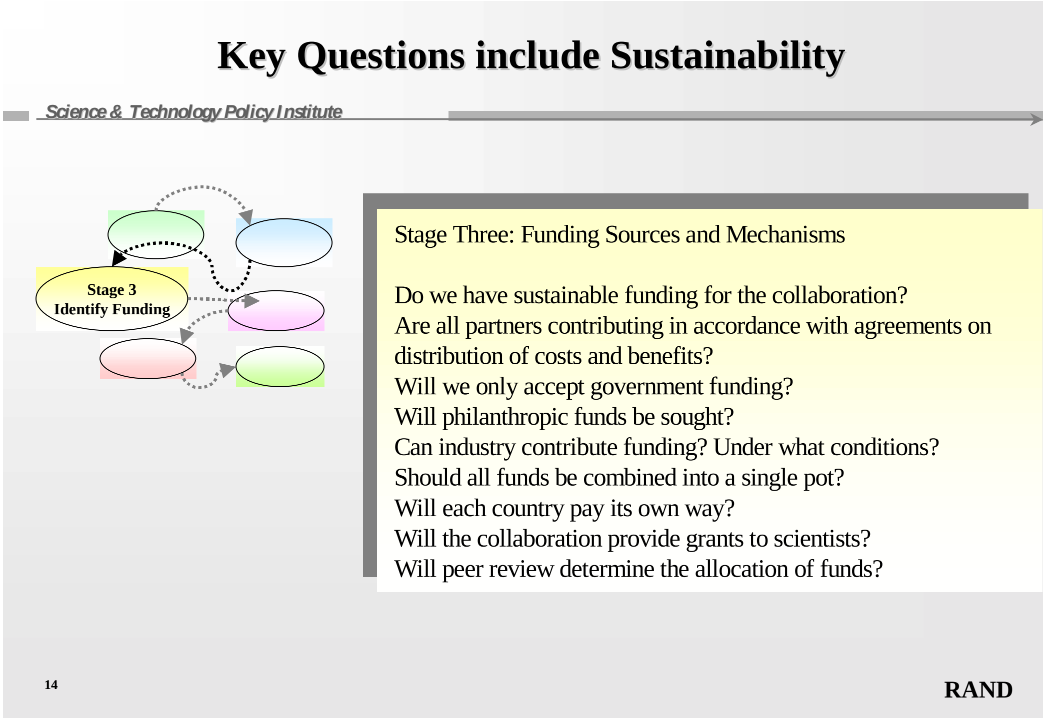
Funding mechanisms:

- *“single-pot” combined funding*
- *dispersed, participant-funded*

13

RAND

Funding: Perhaps no issue is quite as divisive and troublesome as identifying who will fund a new program, how and whether the funds will be shared and allocated, how to sustain funding, and how to ensure that benefits accrue to those providing the support. Funding issues occur at every level. First, they occur at the level of the government initiating the program: Which agencies will fund this effort, or will the legislature be asked to appropriate funds? How can any group be convinced that relinquishing control over national funds to an international body is a good way to spend its money? Once these questions are answered (often helped by the program champions), deciding whether the funds will be co-mingled with those of other governments, or whether funding will be coordinated with others, becomes an issue. Should private or philanthropic funds be included? All these issues came up, and, just as we found with other questions, there is no “right answer.” There are only methods for funding, and lots of questions that should be considered.



Maintaining a stable source of funding is clearly a baseline requirement for any international program. Maintaining a clear line of funds has been one of the central challenges facing these cases. Funding can be contributed by a single source (i.e., governments only), or can be a hybrid of different sources. The cases we examined included all types of funding sources.

The second funding issue reported to us is ensuring that all partners are bringing equitable contributions to the effort as well as obtaining benefits in line with their contribution (even if these are intangible benefits). As one observer told us, “In order to have a collaboration that is ‘win-win,’ all partners must derive a benefit that is commensurate with their contributions.” Should the host country or primary funding country have special voting rights or other privileges?

Alternatively, there may be cases where a partner or applicant, such as a scientist from a developing country, cannot bring an equal financial contribution. This may be acceptable to participants. However, discussing these issues of equitable funding, sharing, or subsidy is important during the early stages of planning and design, an issue cited by several people as important for smooth operations downstream. What should the group do if one country does not pay their share or decides to withdraw from the project?

Within specific projects, a decision should be made whether funding will be used to initiate activities or leverage existing ones. As one champion told us, “If there is not enough money dedicated to new projects, then scientists just collaborate around work they already have under way. If this is going to be new and value-added, you have to fund projects adequately.”

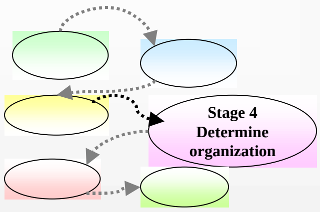
Nevertheless, in two cases we examined, the program and goal were to leverage and share existing research. Funding mechanisms include grants and fellowships, contributions to the operation of laboratories or the building of databases, funding for industrial research, and travel funds to attend conferences and meetings.

Within national governments, the question of who will pay can become important and highly political. U.S. government agencies rarely have budget line items that allow them to commit funds directly to collaboration. As a result, funds are allocated from specific mission-oriented programs. Some program managers in U.S. government agencies are reluctant to commit funds to international activities because they may lose some control over the activity, or it may be viewed as “foreign aid” in another form. Moreover, U.S. government programs are funded on a year-to-year basis, so the question of whether funds will be available to fund a multiyear program is not always known ahead of time.

Sometimes a decision about how a program will be funded depends on the structure of agency budgets. It is far easier if agencies can pay for activities out of budgeted programs rather than needing to transfer funds to a third party. Even so, at least one case we examined, HFSP, government funds are contributed to a "single pot" of funding that is distributed at the international program level. More often, funds for collaboration are dispersed by the agencies, and each participating country or partner funds its own participation in the collaboration.

Publicizing Mission, Inviting Participants are Key Administrative Steps

Science & Technology Policy Institute



Operating procedures include:

– *establishing scientific missions and goals*
– *determining membership and voting rules*
– *deciding on a research agenda*
– *establishing endorsement criteria*
– *determining eligibility for funding or inclusion*
– *inviting proposals or comments*
– *assessing quality of requests for funding*
– *aiding junior scientists*
– *monitoring on-going projects, processes*

15 RAND

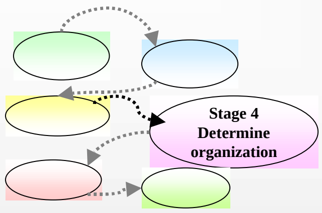
Once decisions are made about actors and champions at the different levels of decisionmaking, the next step is to determine how the new collaboration will be organized, as well as how and where it will be staffed, managed, and evaluated. In several of the cases, these decisions were made at the program organization level, and U.S. government officials had little input into the staffing and management decisions. In two of our cases, however, U.S. government officials worked closely with organizers to make decisions about organization and management structure.

In each of the cases, some combination of the factors listed in the figure contributed to success. These included a flexible structure that could adapt to new information about the impact the program was having. As one told us, “The simplicity of approach has been a large part of the success.” As scientific research developed, the mission, scope, or participants often changed or included new areas of research or new targets. In order to remain current and relevant, program managers solicited input from a number of sectors. They were able to use new information to help keep the programs focused on important and useful questions. Each of these cases, for different reasons, avoided being heavily influenced by political entities. The focus remained on the scientific or technical question and scientists or engineers offered guidance to keep the program moving in the right direction.

Establishing a mission statement for the program, one delineating specific goals, was important to the life of the new organization. We found that, while establishing scientific missions and goals was an important component of the early design phase, S&T produced new knowledge that constantly challenged the programs to revise their vision and their research agenda. Each of the programs adapted its scientific missions to new information. Likewise, determining eligible members of boards, determining the technical people who should be included in program activities, and determining who should receive funds or other support were issues that continually arose as these programs undertook day-to-day operations. These questions were dealt with at all levels of organization: from boards of directors down to the scientists or engineers and staff managing daily interactions. The same is true for establishing endorsement criteria and determining eligibility for funding or participation. These issues were not always worked out harmoniously. In fact, in many cases there were considerable disagreements concerning governance and operating issues. Nevertheless, the programs had the governing structure and communications linkages in place to provide a forum for adjudicating these issues.

Scientists Play a Key Role in Governance

Science & Technology Policy Institute



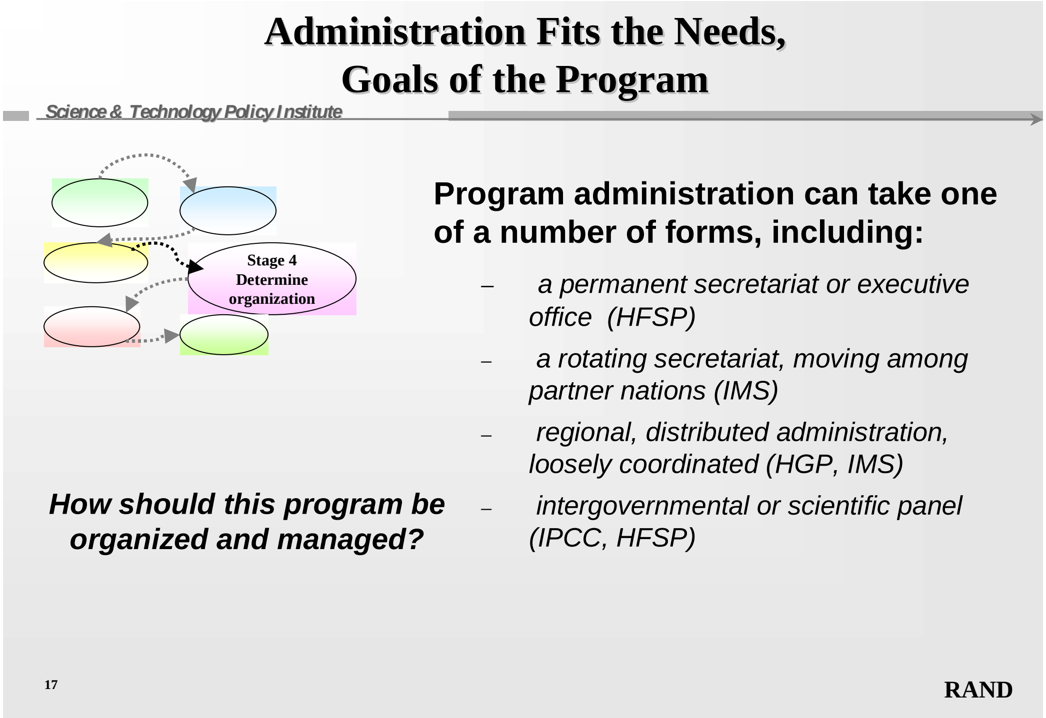
Program governance methods vary, but can include:

- *boards of directors or trustees*
- *boards or councils of scientists and other peer reviewers*
- *consortia of participants*
- *international and non-governmental organizations*
- *steering committees*
- *observer, stakeholder bodies*

16

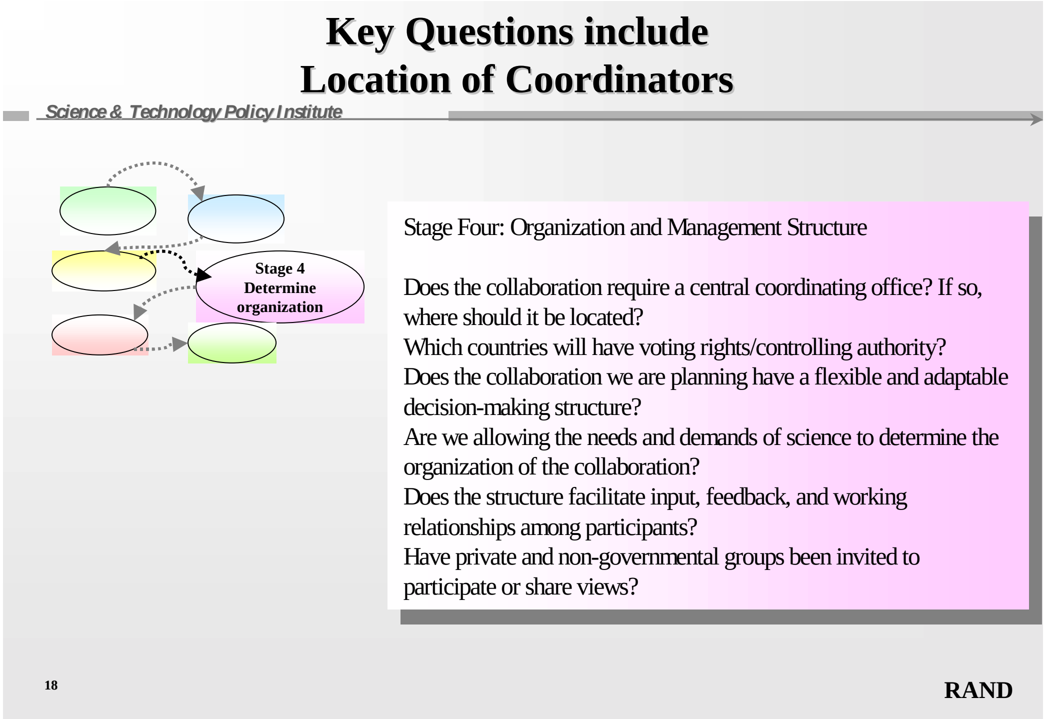
RAND

Each of the cases we examined had different governing mechanisms, and each appeared to work well for that case. For example, HFSP has a board of trustees with a mix of scientists and policymakers, as well as a council of scientists. A small consortium of participants representing the institutions from each of six countries governs HGP. IMS is governed by an international steering committee composed of delegates from industry and research institutions of each participating region. IPCC has a very simple structure but a highly elaborate, bottom-up review process to produce its assessment reports. The IPCC secretariat, bureau, and working groups are responsible mainly for organizational and coordination matters to facilitate the review process. The nature of the governing structure depends on the type of inquiry being pursued and what kind of organizational structure is needed to facilitate the S&T collaborations.



Each of the cases we studied had a different way of operating the program. HFSP has a permanent secretariat who acts as an executive office. HGP has a loosely coordinated structure, where the U.S. National Institutes of Health generally manages the collaboration working closely with the Wellcome Trust and other key institutions involved in the project. IMS has a rotating interregional secretariat as well as regional secretariats who administer the program and projects. IPCC has a secretariat to coordinate organizational matters; three working groups under a bureau headed by the IPCC chair coordinate scientific assessment. The nature of the scientific or technical inquiry, as well as the interests of the participants, helped to determine how the program is administered.

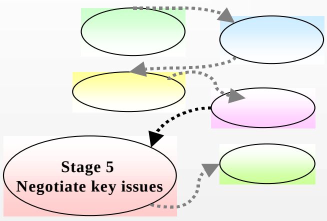
Factors that influence organizational features are: (1) the nature of funding allocation and (2) the method of data-sharing. When a central pot of funds is involved, a centralized secretariat may be needed as a place where potential grantees can contact for information, as is the case with HFSP. Conversely, when each participating country is funding its own research, data-sharing may be the most important function. This does not require a central office; however, it requires a single collection and dissemination point for data. The case of HGP shows how a collaborative program can share data effectively over the Internet.



How the program will be organized and coordinated is a key issue that arose in each of the cases. As noted above, not all collaborations require a central office, but a coordinator is needed for each program. Determining which countries, companies, or groups are "in"—that is, allowed to become full members—and whether new parties will be allowed to join is a particular problem for successful activities. Once the program begins showing results, other parties will naturally want to join. How will this be decided? Each of the cases we looked at decided this differently, some harkening back to their mission statement as a way to retain the original order, others widening the circle to allow new members. Programs with limited funds are less likely to accept new members unless new funds come along as well. Programs that share proprietary data are also less likely to welcome new members who have not yet signed on to the protocols of information exchange and protection.

Negotiating Issues Takes Place Throughout the Life of the Program

Science & Technology Policy Institute



What are the key issues we need to negotiate, monitor?

Early in the program, identify, negotiate major issues:

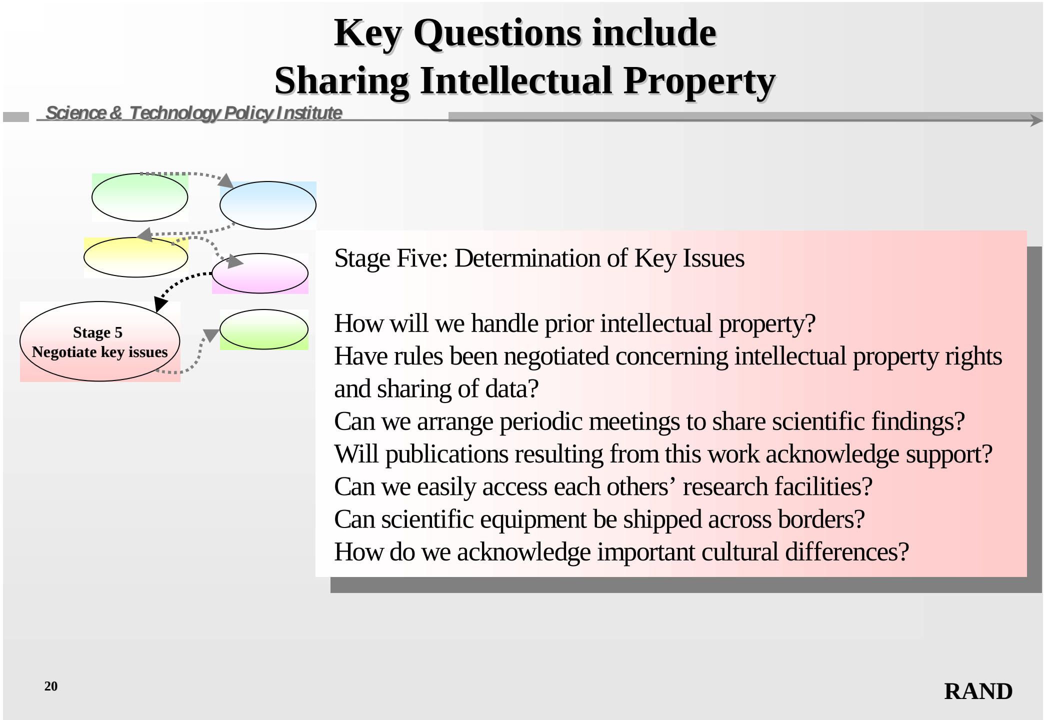
- *intellectual property rights agreements*
- *establishing appropriate legal arrangements, if necessary*
- *addressing access and information sharing issues*
- *publication rights*
- *access to facilities*
- *communication linkages*

19

RAND

In each of the cases we examined, organizers and participants faced key issues that are common. Most reported that identifying and dealing with key issues, particularly early in the process, can be important for successful operation. Questions about protecting existing and newly created intellectual property were key to a number of the cases that we examined. Whether or not the program wanted credit when results were published, how to manage access to facilities, and how to share data were also issues that arose as the programs began operation.

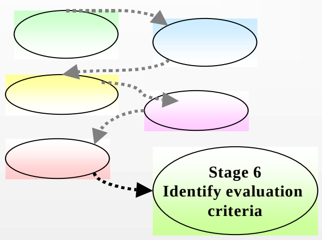
No matter what the specific issue, all of the program managers reported that issues arise throughout the life of the program. To be ready for these issues, a clear and effective method of communicating—top-down and across the different activities being sponsored—was a key factor affecting success. Cultural factors certainly affect operations and should be illuminated, acknowledged, respected, and understood. Face-to-face meetings are required at frequent intervals for organizers as well as for researchers. As one program manager told us, “The collaborators in our program meet face-to-face once a year. This is part of their budget." New information technologies enhance communication, but cannot be relied on as the sole means of communication: A diverse set of communication methods is needed to ensure success.



A sample of the key issues and questions that were reported to us are included here. The figure highlights the role of sharing of intellectual property. In any international venture, the question of sharing and protecting the rights of originators to use the knowledge they create will be an issue. Questions about publication rights should be handled early in any coordinated activity. Acknowledging cultural differences and their effect on the functioning and outcomes of a program was a feature that several people mentioned was important. Partners should be seen and experience themselves as equal partners. There should be a common agreement among participants on the scientific and policy goals that are motivating the organization.

Evaluation is Important at the Political and the Scientific Level

Science & Technology Policy Institute



Features that improve programs:

- *benefits accrue equally to participants*
- *benefits are effectively articulated*
- *evaluation criteria, ideally built into the project and monitored*
- *self-evaluation by project participants assists with feedback*
- *an “exit strategy” or end-point for the collaboration is clearly defined*

Is this program reaching goals set out for it?

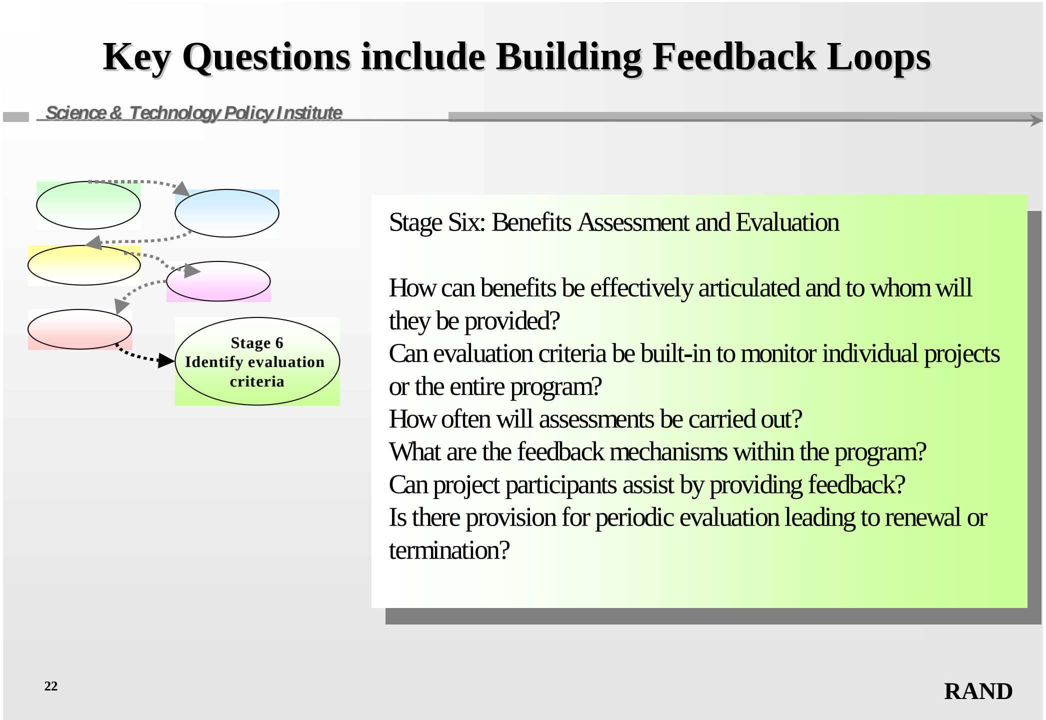
21

RAND

Organizers told us that being able to clearly state the outputs and outcomes of research is a key feature of success. Nevertheless, this is a feature that did not receive adequate attention at the design phase in several of the cases we examined, according to policymakers interviewed. A number of policymakers and organizers recommended building measures of outputs and outcomes into the program design and requiring responses from scientists as to how collaboration helped them reach goals.

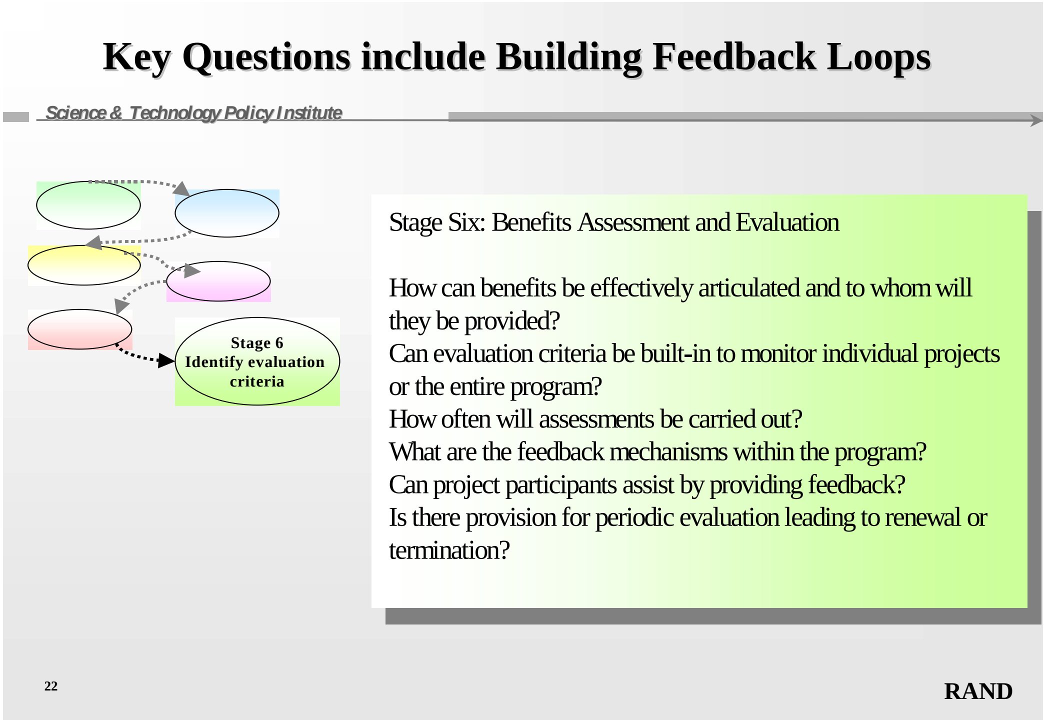
In a larger set of questions, a concern expressed by some federal government agency officials was whether a clear “exit strategy” had been devised for the U.S. government. For example, at what point has the U.S. government reached its goals and therefore bows out of collaborating? This feature was lacking in some of the cases we examined, but it was cited as a factor that should be carefully considered in framing a new collaboration.

In two cases we examined, an independent evaluation of the effectiveness of the program was conducted. This created opportunities in each case to make adjustments to the program based on feedback. A formal, external evaluation helped champions, policymakers, and program managers make their case to other stakeholders, such as legislative bodies, for changes or additional funding as appropriate.



Creating the mechanisms by which the outputs and outcomes of research will be tracked and monitored requires building feedback loops within the program, according to several people we spoke to. “It helps to know how the projects are doing in progress, not just at the end,” one program manager said. In order to do this, periodic meetings help to organize the thoughts of researchers and provide a forum to discuss research progress as well as how well the program is facilitating the cooperative activity.

Criteria for evaluation can be built into the program in a way that helps to monitor administration of the program and research activities. Ongoing monitoring helps make midcourse corrections in cases where specific policies are not working well, or where a project is not going well. Signposts of progress can include, at the administration level, whether grants are being processed on time, whether new applications are increasing, whether participants are providing feedback in a timely fashion, etc. The specific signposts of progress will differ with each program, but the point is to identify and build these in at the beginning of a new activity.



III. NATIONAL BENEFITS

National governments decide to participate in formal international collaborative projects for a number of scientific and political reasons. Distributed projects may be easier to commit to, on one hand, because they do not require the same up-front investment as a megascience project. However, they are more visible than the projects taking place at the level of the individual investigator, thus the raise questions about allocation of resources, sharing of intellectual property and new knowledge, and how to ensure benefits that are different from other types of research projects.

A central finding is that governmental support for collaboration depends on the policy needs, missions, and motivations of those governments. In fact, we found that political and scientific motivations and goals were both important in these cases; U.S. government participation provided political as well as scientific benefits. Measuring the benefits of collaboration goes beyond the evaluation of whether the mechanics of the program were effective. This brings us back into the political realm of decisionmaking, which we touch on briefly in this report.

Ensuring that national goals are met and missions addressed does not mean that research has become “politicized,” our sources told us. Rather, government support for international scientific collaboration was most successful when it was responsive and accountable to scientific and national goals. It may be important for policymakers who consider initiating or participating in a formal collaborative project to be capable of articulating the political (policy) benefits that will accrue from participation, in addition to highlighting the scientific benefits.

National Benefits from a Policy Perspective include Good-will

Science & Technology Policy Institute

From a policy perspective, U.S. parties said that the nation gained:

- *good will as an important and cooperative partner*
- *credibility for U.S. policymakers and for U.S.-funded science*
- *leverage of investment of U.S. dollars*
- *accessing infrastructure*
- *action on research that may not have been funded or conducted otherwise*
- *broader coordinate of decision-making about science*
- *other benefits? Some become apparent over time...*

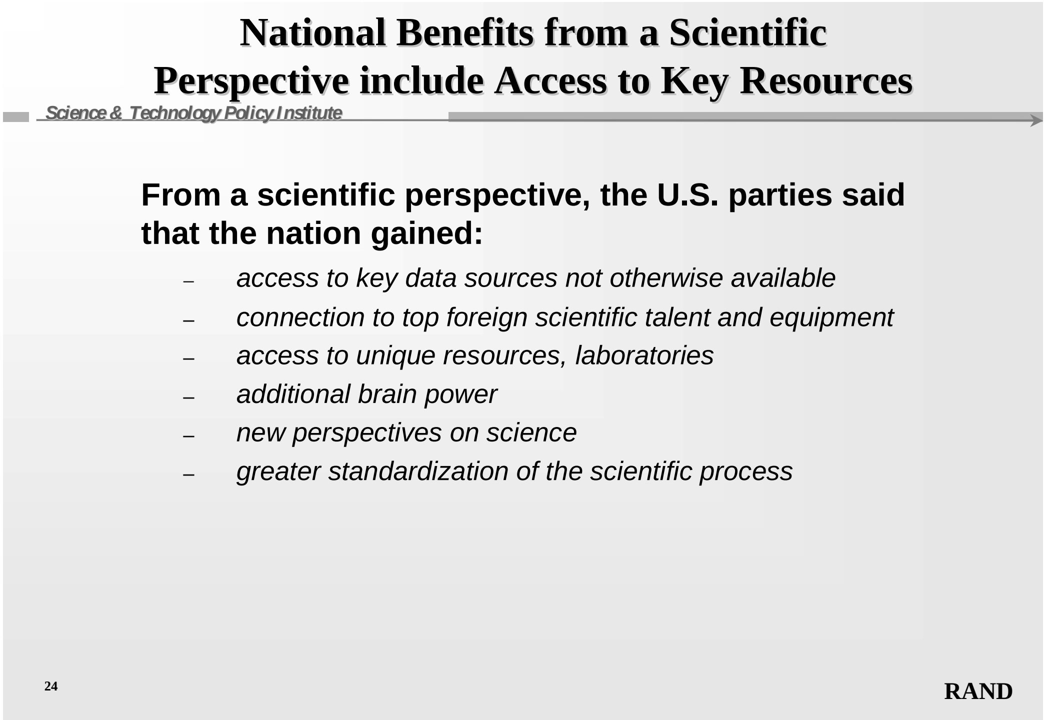
23

RAND

There are a number of benefits that accrue to the United States as a result of collaboration: the benefits are interrelated and overlapping. At the political level, the United States gained good will in that it was seen as a reliable partner by participating in these activities. This can help in the future when the U.S. government seeks to initiate or participate in other ventures. While it was initially difficult for agencies to work out how to participate, they also gained connections and political capital by being attached to successful ventures. This helped U.S. government officials when working with their counterparts in foreign countries. For example, participation in the IPCC helped give credibility to U.S. negotiators working on international climate change negotiations.

Moreover, in the cases we examined, federal government agencies leveraged funding: For the amount that agencies put in, participants estimated that the United States leveraged at least as much investment from other sources. In cases where U.S. industry participated, federal government agencies also leveraged funds by pooling them with industry funds. In some cases, such as IMS, industry funds paid for the research[2], and U.S. scientists were able to benefit. In addition, U.S. scientists gained access to top scientific talent, data, and research facilities in other countries.

[2] The U.S. government did not provide funds directly to IMS, although they did fund several projects through NSF. Other governments did provide funds, however.



Based on the comments we received as well as published reports, many scientific benefits also resulted from these collaborations. In some of the cases we examined, data was shared under the collaborative venture that would have been difficult to share otherwise. International databases have been created that simply would not have existed without collaboration. Such is the case with the genome project. Participation in collaboration can bring together scientists who would have found it difficult to work together without a specific program, enhancing the field as a whole. As one scientist told us, "…IPCC definitely brought scientists together who I am sure would not have done so otherwise." Moreover, the legal and organizational structure offered by a program can encourage R& that might not have taken place: The IMS terms of reference, for example, particularly sections dealing with intellectual property rights, have allowed U.S. companies to protect their proprietary information even while their scientists engage in meaningful and substantive cooperation.

In several cases, top scientists who had received funding from a collaborative project came to conduct research in the United States. This was the case with

HFSP, where many scientists spent time working in U.S. labs on neurosciences research, enhancing the productivity of U.S. scientists.

Final Observations

Science & Technology Policy Institute

- Distributed research is an effective form of collaboration
- Programs demonstrate new organizational structure
- The practices uncovered can be a “toolkit” for others
- Evaluation must account for this form of collaboration
- Comparing RAND’s findings to others will be crucial

25

RAND

In conclusion, we found that distributed research projects can be an effective way to facilitate international collaboration. Within the overall *class* of programs that might be called distributed international collaboration, different ways of managing them will become apparent based on the goals of the participants, the nature of the science being pursued, and the amount of resources available. The tools to accomplish this organization are different from the ones used for megascience projects or for individual research efforts. Because they are different, these programs also require evaluation tools that reflect their unique features and benefits to stakeholders. Further policy research comparing all these characteristics across countries involved and analyzing various national and disciplinary approaches will help to get a better sense of how to better manage these programs in the future.

References

Advisory Council on Science and Technology, Reaching Out: Canada, International Science and Technology, and the Knowledge-based Economy, Report on the Expert Panel on Canada's Role in International Science and Technology. Ottawa, Canada: Industry Canada, 2000.

Gibbons, M., et al., *The New Production of Knowledge: The Dynamics of Science and Research in Contemporary Societies*, London, England: Sage Publications, 1994.

National Science Board, Toward a More Effective Role for the U.S. Government in International Science and Engineering. Arlington, Virginia: National Science Foundation, 2001.

National Science Board, Science and Engineering Indicators 2000. NSB 00-1. Arlington, Virginia: National Science Foundation, 2000.

Wagner, C. et al., Science and Technology Collaboration: Building Capacity in Developing Countries. Santa Monica, CA: RAND, 2001.

Wagner, C. et al., International Cooperation in Research and Development: An Update to an Inventory of U.S. Government Spending. Santa Monica, CA: RAND, 2000.