
Finding Our Future: A Research Agenda for the Research Enterprise

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Executive Summary

For more than 50 years, the U.S. government has supported and encouraged scientific discovery through grants to researchers in laboratories and educational institutions around the nation. From its modest beginning in the late 1940s, this research enterprise has grown, matured, and evolved into a \$112-billion endeavor involving thousands of organizations and investigators representing every scientific discipline and field of knowledge. More than 20 government agencies contribute to federal investments in basic and applied research, development, and supporting equipment and facilities. Total federal R&D spending has increased 11-fold since records began in 1949, rising from \$940 million to over \$100 billion.

The research enterprise is not only large, complex, and important in its own right, it is also embedded in a political, economic, and social environment that exerts strong influences on research topics and priorities, methods and principles, and opportunities for involvement. Given the size, scope, complexity, diversity, and growth of the research enterprise in the U.S., the mechanisms that support research have come under increasing stress and increasing scrutiny. Systems, staff, and processes that were designed to handle smaller, simpler programs are now straining to support new, high-volume, high-cost programs such as those in information technology, bioterrorism, and climate change. At the same time, management and accountability requirements have been strengthened with special emphasis on performance measurement. Given these trends, what knowledge and action are needed to shape the future of grant-supported research? This report offers a vision of the ideal research enterprise and lays out a supporting research and action agenda to help achieve it.

The ideal research enterprise

The research enterprise is essential to continued economic growth, global competitiveness, and societal well-being. In an ideal form, it would:

- invest in work that impacts significant social and scientific challenges and responds to new discoveries
- foster a wide network of relationships that generates relevant questions, recognizes emerging issues, and sustains significant, cutting-edge programs of work
- put resources into the hands of qualified grantees through value-added decision processes that are fair, quick, and open
- develop and nurture the human and organizational capacity to conduct research
- take investment risks that encourage discovery while managing administrative risks associated with accountability
- use rules-based business processes that are clear and seamless for all involved
- put management and support work in the hands of well-prepared individuals and organizations
- strive for excellence and welcome innovation in its own operations
- understand, represent, and advocate for its community
- recognize and communicate its impact on the world

The challenges

Today, the grants-supported research enterprise is an amalgam of highly interdependent organizations, different value systems, multiple business processes, and competing priorities. These characteristics create opportunities for the enterprise, but they also present significant challenges. Some of these challenges are inherent in the nature of the enterprise; others reflect trends in the environment and their influences on the way research is conducted. These challenges include:

Organizational complexity and diversity—Thousands of organizations with different management, technology, and policy frameworks and a wide variety of

overlapping and distinct goals come together to make up the research enterprise.

Rapid technological change—Modern technical tools and the work we can do with them are part of the legacy of scientific research. But technological change is also a source of organizational and operational frustration.

Slow organizational and interorganizational adaptation to change—The ways organizations define themselves, relate to the environment, approach their work, and select processes, tools, and techniques all evolve more slowly than the technology around them. This is compounded when multiple independent organizations must work together.

Conflicting approaches to risk—The juxtaposition of two very different approaches to risk presents an ongoing conundrum for the enterprise. It needs policies, procedures, and processes that assure public trust, but also the freedom to take the risk of investing in new and untried ideas.

Interdisciplinarity and research partnerships—Today's societal needs and scientific challenges demand interdisciplinary studies to uncover new knowledge not discoverable using traditional approaches. This kind of research can be powerful, but it is also complicated, expensive, and counter to prevailing traditions.

Increasing accountability and performance requirements—Research agencies are struggling to find useful ways to address these requirements in the context of long-term, uncertain investments in science. At the same time, these initiatives may encourage agencies to better meet another long-standing need—to communicate in plain language about the value and the progress in science.

Misalignment of multiple policies and operating cycles—The policy and regulatory frameworks governing organizations throughout the enterprise

are increasing in both quantity and variety. Repetitive but misaligned business cycles, such as the federal budget cycle and traditional academic calendars, regularly challenge the operational capacity and goals of the enterprise as a whole.

Since the mid-1980s, federal agencies and their research partners have worked to address these challenges in programs like the Federal Demonstration Partnership, various electronic grants administration projects at state and federal levels, and a new Federal e-government initiative focused on grants making. Despite the progress made by these efforts, the challenges persist. The emergence of the ideal research enterprise will require better knowledge of its components and dynamics, and appropriate action to integrate that knowledge into practice. To make further progress, new streams of research as well as several practical actions are warranted.

Thematic research agenda

The complexity of the research enterprise cannot be understood through the lens of a single discipline or analytical model. No one viewpoint or perspective provides a complete picture. However, five themes consistently emerge as useful for studying and improving the enterprise:

- understanding the multiple value propositions that stakeholders bring to the enterprise and how they are aligned, complementary, or in conflict
- understanding how work is done by individuals and groups within and across organizations
- understanding how individuals, groups, and organizations collaborate across the boundaries of structure, time, and place
- understanding how knowledge is captured, managed, and used within the enterprise
- understanding how to choose, use, manage, and support information technology investments

Integrative research agenda

While each theme above suggests important research questions of its own, a different set of questions emerges from a more holistic look at the research enterprise. These questions highlight the interdependencies among the themes. They might be thought of as integrative goals that span the thematic areas and move us toward practical applications. These include research that will generate and test:

- new ways to identify and define the substantive goals of research initiatives
- new models of the grants-supported research process that make different assumptions about roles, relationships, and responsibilities of the various players
- alternative strategies and new technologies to support the review and selection of research proposals
- incentives for collaboration across disciplines, roles, and organizations
- new technologies for multimedia proposal development, submission, and management
- information-centric processes as tools for an enterprisewide orientation

Action recommendations

Finally, we offer the following recommendations to initiate and inform discussions about action that can begin today to move the research enterprise toward the ideal state:

- document and evaluate the existing models and philosophies of grants making
- support and improve communication across research and administrative professions within the enterprise
- identify and share best practices in communicating within the enterprise and with the public about science

- continue to invest in the identification and diffusion of best practices in communicating with the public about science
- continue to invest in the development, deployment, and adoption of standards for common data, tools, and activities
- experiment with business models that reflect different assumptions about institutional relationships
- continue to experiment with virtual collaboration work models and technologies
- identify and apply the knowledge gained through funded research to the needs of the research enterprise itself
- coordinate announcements of focus areas across the enterprise

Together with the research agenda, these recommendations comprise a balanced strategy for building future knowledge while acting on today's promising ideas.

Chapter 1. An Ideal Research Enterprise

Organized research in the U.S. involves billions of federal and private dollars and dozens of agencies. It also comprises large numbers of research institutions and individual investigators in a complex set of relationships with funding organizations and with one another. This report refers to that combination of investigators, sponsoring organizations, and research institutions as the research enterprise. Any effort to move that enterprise toward an ideal future demands a solid understanding of its current make-up and operation. This report concentrates primarily on the federally funded portion of this enterprise, but necessarily includes attention to broader issues as well.

For more than 50 years, the U.S. government has supported and encouraged scientific discovery through grants to researchers in laboratories and educational institutions around the nation. From its modest beginning in the late 1940s, this research enterprise has grown, matured, and evolved into a \$112-billion endeavor involving thousands of organizations and investigators representing every scientific discipline and field of knowledge. The research enterprise encompasses three main kinds of work—basic research, applied research, and development activities, collectively referred to as research and development or R&D.

The FY2003 federal budget describes *basic research* as “systematic study directed towards gaining greater knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind.” *Applied research* is “systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met.” *Development* is “systematic application of knowledge toward the production of useful materials, devices, and systems or methods, including design, and development and improvement of prototypes and new processes to meet specific requirements.”

Of all planned federal R&D spending for FY2003, about 23 percent will go to basic research, another 23 percent to applied research, and the remaining 54 percent to development and research facilities.

Size, scope, complexity, and diversity

More than 20 agencies contribute to federal investments in basic and applied research, development, and supporting equipment and facilities. According to the FY2003 federal Science and Technology Budget, the largest research budgets are in the National Institutes of Health (\$20.3 billion), NASA (\$10.1 billion), the Department of Energy (\$8.5 billion), and the National Science Foundation (\$3.7 billion). Total federal investments in research and development represent an increase of eight percent over 2002 and more than 34 percent since 2000. Total federal R&D spending has increased 11-fold since records began to be kept in 1949, rising from \$940 million to over \$100 billion. A few recent statistics illustrate the size and scope of the enterprise:

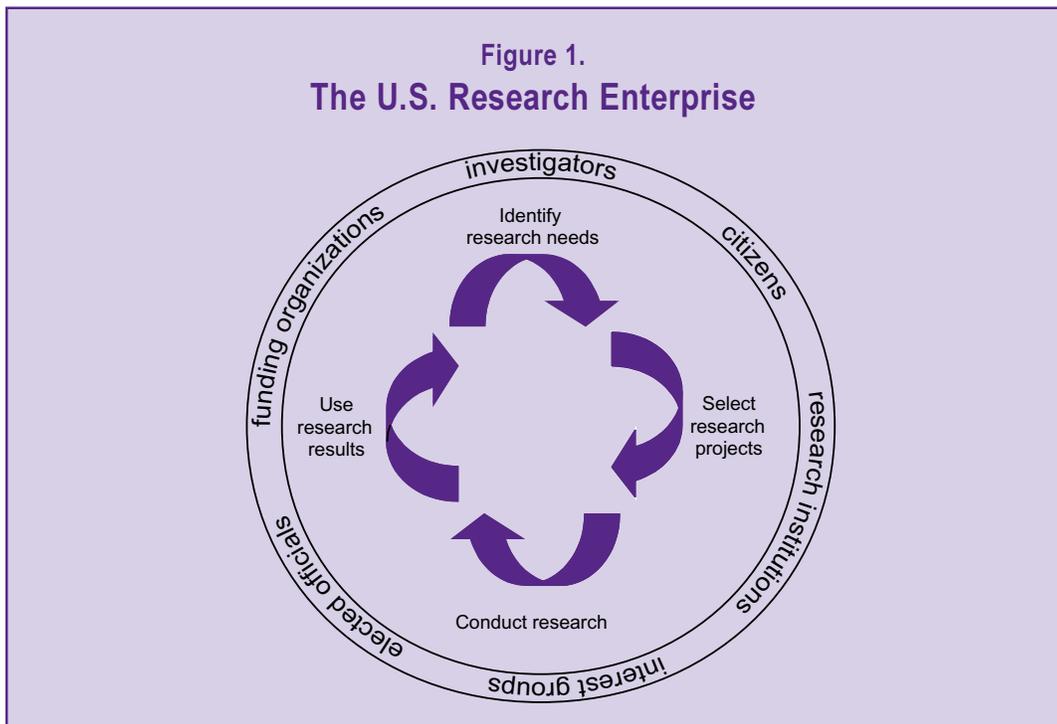
- In 2001, the National Institutes of Health awarded more than 40,000 competitive and noncompetitive research and development grants worth \$14.9 billion to investigators at more than 2,500 research institutions. The average size of an award was \$305,000. Over 27,000 individual investigators applied for NIH's competitive awards.
- In the same year, the National Science Foundation received nearly 32,000 new proposals and made awards to about 3,400 or 10.6 percent. The median award amount was \$75,000 for a two-and-a-half-year project. This modest figure masks the range of award sizes which rise to over \$100 million for specially targeted multi-year, multi-institutional partnership programs.

- A single institution in a single year may receive and manage only a handful of small grants, or, like the University of Illinois at Urbana-Champaign, may receive from NSF alone more than 300 awards totaling over \$120 million.
- A single investigator may have research funding from multiple public agencies as well as from private or foundation sources—and each sponsor has its own goals, policies, and practices.

The research enterprise is not only large, complex, and important in its own right, it is also embedded in a political, economic, and social environment that exerts strong influences on research topics and priorities, methods and principles, and opportunities for involvement. The White House, congressional committees, academic societies, consumers and citizens, professional associations, and interest groups all play some role. Figure 1 suggests the complexity and diversity inherent in the research enterprise.

It can be thought of as an ongoing cycle of overlapping activities, each involving influential stakeholders in a variety of relationships.

The process of identifying research needs involves all stakeholders and reflects collectively the concerns of society, the priorities of political leaders, and the intellectual commitment to the discovery and pursuit of new knowledge. Selection involves the process of soliciting and encouraging research proposals, evaluating them, and choosing a portfolio of projects that collectively addresses the needs from a variety of perspectives, using different approaches and methods. Research is conducted in a variety of settings by trained investigators whose goals include discovery, testing and validation of concepts and theories, knowledge building within and across disciplines, and the production of new tools, methods, and devices for practical use. Research results are used to advance theoretical knowledge, to generate practical solutions to problems, to train the



next generation of research scientists, and to enhance the knowledge and education of the public. None of these activities is in the domain of a single stakeholder. As a result, each domain can encompass competing values, delicate negotiation, and ongoing conflict.

Stresses and performance challenges

Given the size, scope, complexity, diversity, and growth of the research enterprise in the U.S., the mechanisms that support research have come under increasing stress and scrutiny. Systems, staff, and processes that were designed to handle smaller, simpler programs are now straining to support new, high-volume, high-cost programs such as information technology research (ITR) at NSF, cancer and bioterrorism research at NIH, or the climate change program partnership among NASA, the National Oceanographic and Atmospheric Administration (NOAA), the Department of Agriculture, the Department of Energy, and NSF. Each of these programs, and others like them, involve thousands of investigators, universities, and laboratories.

At the same time as the enterprise is developing new research models management and accountability requirements have been strengthened with the passage of the Government Performance and Accountability Act (GPRA) and the President's Management Agenda. Both require agencies to employ performance measures that address program achievements and managerial accountability. Heightened human subjects protections place additional procedural requirements and record-keeping responsibilities on funders, investigators, and their institutions. In the research institutions themselves, the multiple business processes, rules, and expectations of different funding organizations cause high overhead and opportunity for error in processing awards and accounting for and reporting results. Several initiatives to address and simplify the multiplicity of

federal grants-making activities are focusing on electronic grants administration within and across various agencies. The Federal Commons Project, for example, is a single portal that consolidates access to federal grants programs, and other aspects of grants management.

Finally, while research itself is burgeoning, traditional publication outlets for releasing research results reach only a narrow audience. They do little to communicate and demonstrate the value of R&D investments in plain language that crosses disciplines and makes sense even to much of the research enterprise, let alone to the public. These and other challenges are discussed more fully in Chapter 2.

Characteristics of the ideal research enterprise

The research enterprise is essential to continued economic growth, global competitiveness, and societal well-being. Its contributions over the past five decades amply demonstrate the value of sizable investments in science, technology, and engineering. These contributions and benefits flow from a mixed portfolio of basic, applied, and development work, with long-, medium-, and short-term time horizons. Despite its historical record of achievement and value to contemporary society, the enterprise faces broad challenges. Many specific problems and potential solutions abound. To respond to these far-reaching and interconnected challenges and problems, the enterprise will need a clear focus on the ideals to be achieved, rather than on problems to be solved. Those ideals can be stated in simple terms as characteristics of the ideal research enterprise of the future:

Invests in work that impacts significant social and scientific challenges and responds to new discoveries—It is capable of identifying trends, convergences, and emerging needs. The ideal research enterprise is open to new ideas, but also pursues the development of past discoveries.

It supports a broad portfolio of basic research that leads to new knowledge, applied research that brings that knowledge closer to useable form, and the development of tools, systems, methods, and materials that embody knowledge.

Fosters a wide network of relationships that generates relevant questions, recognizes emerging issues, and sustains significant, cutting-edge programs of work—The ideal enterprise engages all of its stakeholders in the key processes of agenda setting, community building, and capacity development. Stakeholder groups include political leaders, researchers, research institutions in higher education and elsewhere, grants-making organizations of all kinds, science educators, and interest groups whose concerns generate research topics and represent consumers of research results.

Puts resources into the hands of qualified grantees through value-added decision processes that are fair, quick, and open—Ideal decision processes are sensible and add something of value at every step. They are open and understandable to all interested parties. They treat proposers and their ideas fairly and take no longer than necessary to serve their stated purpose.

Develops and nurtures the human and organizational capacity to conduct research—The enterprise makes both broad and targeted investments in the size and quality of the community of scholars. It acts directly to increase the total number of scientists and engineers, to enhance the quality of doctoral education, to introduce research principles and careers at every level of education, and to support development of under-represented groups. It encourages and guides the entry of new investigators and organizations.

Takes investment risks that encourage discovery, while managing administrative risks associated with accountability—The ideal research enterprise is a master of risk management. It understands that research is a process of experimentation and discovery

The characteristics of an ideal research enterprise

An ideal research enterprise:

- invests in work that impacts significant social and scientific challenges and responds to new discoveries
- fosters a wide network of relationships that generates relevant questions, recognizes emerging issues, and sustains significant, cutting-edge programs of work
- puts resources into the hands of qualified grantees through value-added decision processes that are fair, quick, and open
- develops and nurtures the human and organizational capacity to conduct research
- takes investment risks that encourage discovery while managing administrative risks associated with accountability
- uses rules-based business processes that are clear and seamless for all involved
- puts management and support work in the hands of well-prepared individuals and organizations
- strives for excellence and welcomes innovation in its own operations
- understands, represents, and advocates for its community
- recognizes and communicates its impact on the world

that often cannot be directed toward predetermined outcomes. It therefore takes the necessary risk of investing in a wide variety of ideas, methods, and investigators who show promise, knowing that not all of them will succeed in their goals. At the same time, the ideal enterprise balances its risk-taking in support of discovery with its fiduciary responsibility for enormous amounts of funding. It builds systems and controls that limit the risks of administrative error or abuse by documenting decisions and accounting for the proper use of awards and administrative funds. It manages the peaceful coexistence of these two ways of conceptualizing risk by balancing their goals and methods, and by constantly monitoring and adjusting them so that they do not work against one another.

Uses rules-based business processes that are clear and seamless for all involved—The ideal research enterprise is a highly functional business endeavor that takes an enterprisewide view of its business processes. It recognizes the implications of both intra- and inter-organizational work flows and information exchanges. It uses business processes that serve functional needs and follow explicit, well-understood rules. Each process generates, draws upon, and maintains pertinent records and information. The processes and their associated information are well integrated across functions and organizational boundaries. They support useful, cost-effective relationships among the variety of organizations involved in grants-funded research.

Puts management and support work in the hands of well-prepared individuals and organizations—Many kinds of skills and knowledge are present in the operational domain of the ideal research enterprise. Administrators, operations and support staff, program managers, financial experts, Information Technology (IT) professionals, communication specialists, data analysts, and human resource staff all play important roles. In this ideal enterprise, each kind of professional specialty is

adequately staffed, well trained, and assigned the responsibilities it is best suited to handle.

Strives for excellence and welcomes innovation in its own operations—The research enterprise is self-reflective, regularly evaluates itself, and embraces intellectual, organizational, and operational innovations to constantly improve performance. As a consequence it is constantly growing and changing.

Understands, represents, and advocates for its community—Like all important aspects of our society, the research enterprise competes for limited public attention and financial resources. The ideal enterprise is self aware; it understands the kinds of work being done, the people and organizations involved, their needs, and their capabilities. It is activist and articulate; the enterprise mobilizes its stakeholders to advocate for policies, priorities, and resources that will sustain its contributions and its potential for discoveries that benefit society.

Recognizes and communicates its impact on the world—The ideal enterprise fully recognizes the results, outcomes, and impacts of the work it embodies. It can communicate about them within the scientific community and to society at large. It tracks research results and demonstrates in plain language how, over time, they contribute to a better life for individuals and communities. It explains the essential value of investments in basic, applied, and developmental projects and shows how each contributes to new knowledge and its practical application in business, industry, government, and community.

Chapter 2. Challenges Confronting the Research Enterprise

Highly interdependent organizations, different value systems, multiple business processes, and competing priorities characterize the research enterprise. These characteristics create opportunities for the enterprise, but they also present significant challenges. Some of these challenges are inherent in the nature of the enterprise, others reflect trends in the environment and their influences on the way research is conducted. The consequences of these challenges include inefficient resource utilization, missed opportunities to advance science, and reduced ability to garner public support for research.

Inherent challenges

The research enterprise faces a number of challenges that arise from its dynamic, multi-organizational nature. They stem from the complexity of the interorganizational arena, from the rapid pace of technological change and the comparatively slow pace of organizational adaptation, and from conflicting concepts of risk.

Organizational complexity and diversity—Thousands of organizations with different management, technology, and policy frameworks and a wide variety of overlapping and distinct goals come together to make up the research enterprise. To some extent, these differences reflect different value propositions embedded in their individual missions and cultures. Consider these complementary, competing, and conflicting values which must be reconciled as organizations work across the enterprise: discovering new knowledge, producing practical value, conducting fair and open peer review, providing funding to the best scientists, providing opportunity to a broad range of scientists, ensuring resource availability, and achieving technical compliance and financial integrity.

Different work models and priorities among these organizations add both complexity and

diversity. Some organizations are open and flexible, others are formal and structured. Some are slow to respond to change, others respond quickly to new ideas and discoveries. These different organizational designs and philosophies result in different approaches to work and different priorities with respect to the grants-funded research process. Some grants-making organizations are strongly committed to blind peer review to select the best projects. Others believe the best way to cultivate sound and important new research ideas is through ongoing working relationships between program officers and investigators. Some grants makers use both approaches. Some universities provide sophisticated administrative and technical support to researchers as they work with grants makers; others do not. Each grants-making organization deals with many different grantees, while a single grantee may need to respond to the missions and rules of multiple funders. Navigating through this web of rules and cultures adds costs and complexity to the entire system.

Rapid technological change—The research enterprise can take pride in technological progress. Modern technical tools and the work we can do with them are part of the legacy of scientific research. But technological change is also a source of frustration. The people, processes, and organizations that make up the research enterprise face the same issues that confront every other kind of organized endeavor. Past investments in technology create sunk costs and legacy systems which offer stable and consistent ways of working, but which eventually become barriers to the very new developments we most wish to adopt. Moreover, the many organizations within the enterprise make independent decisions about technology investments resulting in uneven infrastructure, inconsistent capacity to engage in electronic communications, and incompatible skills, standards, and work processes.

Slow organizational and interorganizational adaptation to change

—The ways organizations define themselves, relate to the environment, approach their work, and select processes, tools, and techniques all evolve more slowly than the technology around them. The impacts of this reality are compounded when working in an interorganizational enterprise. The rates of change and the nature of change vary from one place to another. Changes in some organizations, especially in the granting agencies that are central to the enterprise, can affect the flow of information throughout the system. Electronic grants administration, for example, requires research institutions to adjust or reconcile their internal management needs with the changing organizational and management demands of the granting agencies that provide their main funding. Another organizational change has to do with the recent focus on cross-disciplinary research. Both granting agencies and universities are organized along strong disciplinary lines, yet both are working toward more multidisciplinary research programs. This evolution creates important tensions between new research goals and traditional organizational systems for designing work, allocating resources, and measuring and rewarding performance.

Conflicting approaches to risk—The nature of research—inquiry into the unknown—involves risk taking. This is like the risk an investor accepts in creating a mixed portfolio of assets. The performance of some of the investments are quite predictable, others less so. Some may be quite speculative, but these represent the calculated risk that either a loss or a great gain may be possible. Contrast this kind of risk assessment with the traditional compliance and accountability activities of public organizations. Rules-based systems, audit programs, and internal controls are all put in place to ensure predictable performance and to prevent errors, fraud, or other misuse of public resources. These accountability

tools have a legitimate place in the research enterprise as well, given its distribution of billions in taxpayer dollars. The juxtaposition of these two very different approaches to risk presents an ongoing conundrum for research agencies. They simultaneously need policies, procedures, and processes that assure public trust, as well as the freedom to take the risk of investing in new and untried ideas.

Emerging challenges

Progress toward the ideal research enterprise of the future is further complicated by emerging trends that directly challenge the enterprise. These include new approaches to conducting research, increasing demands for government accountability and management performance, and misalignment of policies and practices within the enterprise.

Interdisciplinarity and research

partnerships—Research has traditionally been conducted by individual investigators focused on a single discipline or subdiscipline. However, today's societal needs and scientific challenges demand interdisciplinary studies to uncover new knowledge not discoverable using traditional approaches. Several major research programs have been launched recently that emphasize cross-disciplinary research partnerships. These include the National Partnership for Advanced Computational Infrastructure sponsored by NSF, the Biodefense Program at the National Institute of Allergies and Infectious Diseases at NIH, and the Multidisciplinary Research Program, sponsored by the Department of Defense's University Research Initiative (URI). Unfortunately, regardless of the logic and benefit of this new approach to science, interdisciplinary research partnerships are more difficult to form and manage than traditional studies. They are harder to assess and harder to communicate about. The formal structures of the research enterprise have not been

organized to support an interdisciplinary approach. Universities are organized along traditional disciplines. Typically, grants-making organizations and professional societies are organized in the same way. Traditional disciplines also largely define the reward structures and careers of individual scientists.

Interdisciplinary research is not only complicated, it is expensive. It involves higher costs for coordination and communication. It requires reaching out beyond traditional models and seeking new ways to amass and deploy resources and to build and manage research teams. Much of the burden of these new requirements falls to scientists and their organizations. They must reach beyond their long-established, discipline-based networks to develop a language and a common framework for thinking about the areas where disciplines do or could overlap. To establish a partnership, they must find funders who are also interested in, willing to, and capable of supporting interdisciplinary research. Research funders who seek interdisciplinary proposals face the difficulty of evaluating the ideas either directly or through peer review panels that understand this new way of working. For the investigators, the reward systems of their universities may not recognize or reward this kind of work with tenure and promotion.

Increasing accountability and performance requirements—The trend in the federal government toward increased accountability and performance measurement has had a general effect on the research enterprise for many years. Specific legislation focusing on increased accountability and efficiency in the research enterprise, per se, is a more recent phenomenon. For example, the Government Paperwork Reduction Act of 1993 is focused on overall government efficiency, while the Federal Financial Management Assistance Improvement Act of 1999 (PL 106-107) is specifically focused on increasing the accountability and the efficiency of research programs. These are just two of many federal laws and policies that circumscribe the management activities of research agencies.

Selected Federal Laws and Policies Affecting Grants Management

Budget and Accounting Act, as amended (31 U.S.C. 11)

Chief Financial Officers Act (31 U.S.C. 3512 et seq.)

Computer Security Act (40 U.S.C. 759)

Federal Financial Management Assistance Improvement Act of 1999 (PL 106-107)

Federal Property and Administrative Services Act, as amended (40 U.S.C. 759 and 487)

Government Paperwork Elimination Act of 1999 (PL 105-277)

Government Performance and Results Act of 1993 (PL 103-62)

Information Technology Management Reform Act of 1996 (Clinger-Cohen Act) (PL 104-106)

OMB Circular A-130, Management of Federal Information Resources

Paperwork Reduction Act of 1980

Paperwork Reduction Act of 1995 (44 U.S.C. 35)

Privacy Act, as amended (5 U.S.C. 552a)

The President's Management Agenda is pushing all federal agencies to improve their performance in five critical areas: financial management, management of human capital, competitive sourcing, budget and performance integration, and expanded use of e-government. As a result, changes are being made in management models, work cycles, processes, and system designs within federal grants-making organizations. Because responsiveness and accountability are linked to risk management, research agencies are struggling to find useful ways to address these requirements in the context of long-term, uncertain investments in science. What needs to be measured, how it can be measured, and what the measurement tells us, are questions being considered at many organizations within the enterprise. At the same time, these initiatives may encourage agencies to better meet another long-standing need—to communicate in plain language about the value and the progress of science.

Misalignment of multiple policies and operating cycles—The research enterprise invests regularly and heavily in overcoming or compensating for misalignments in the policy and regulatory environment and in the key cycles that govern work throughout the enterprise.

The policy and regulatory frameworks governing organizations throughout the enterprise are increasing in both quantity and variety. A single granting agency applies its own policies and regulations, while researchers and research institutions must comply with the rules of each granting agency they work with. Identifying, understanding, and reconciling the differences is becoming a significant burden. Many of the differences are based on unique requirements or conditions for individual granting organizations. Others are evidence of the uncharted evolution of business practices. The process of identifying, understanding, and working appropriately with these differences is costly and frustrating to most research institutions.

Repetitive but misaligned business cycles regularly challenge the enterprise. The federal budget process frequently informs granting agency program officers late in the process about how much money they will have available to them. As a result, they have to speculate about funding as they work with researchers to identify and cultivate new ideas, build innovative partnerships, and seek the wisest investment of funds. If funding levels are out of line with these discussions, either valuable time is lost working on ideas that cannot be supported or not enough groundwork is laid for programs that then need to be launched quickly. In the latter case, research scientists must be brought quickly into the pipeline through calls for proposals and reviewers. These narrow windows of opportunity limit participation and force incomplete proposal development, especially for programs that seek partnerships across disciplines or institutions. On a more operational level, award decisions are often made at awkward points in the academic year when investigators and graduate students have already committed to other work, thus delaying the start date or the full staffing of funded projects.

Recent efforts to meet the challenges

A number of efforts are in place to address these challenges. Some are taking place within specific agencies or in small groups of agencies, some are grassroots efforts, others are driven by political leadership. Some relate to research funding, others address distribution of program funds. Some are moving into their second decade of effort, others are just beginning. All are moving forward at different paces and with different definitions of progress and success. The overall impact of these programs is not yet clear, but they are making real contributions to our understanding of the issues and possible solutions.

Federal Demonstration Partnership

(FDP)—Launched in 1986, the FDP is a cooperative arrangement among federal granting agencies and grant recipients to improve the processes of proposal review and funding for research. Eleven federal agencies, 65 research institutions, and five professional organizations participate in the effort, which is convened by the National Academy of Sciences' Government—Industry—University Research Roundtable. The goal of FDP is to increase research productivity while maintaining responsible stewardship of federal funds by streamlining funding procedures and reducing the workloads of proposal writers and research administrators. The Partnership sponsors demonstration projects that test new ideas to achieve these goals. Early efforts focused on key rules that make it easier for grantees to launch and manage projects. Current efforts are focused on more global needs for electronic grants administration.

Electronic grants administration

projects—Electronic grants administration has been under development in various forms for several years. The large community served by NSF, for example, has benefited from FastLane, which reduces the amount of paper processing by streamlining and automating as much of the proposal preparation, submission, and management process as possible. Similar efforts are underway at NIH in their Electronic Research Administration (ERA) program. A governmentwide effort entitled the Federal Commons Project was initiated in response to Public Law 106-107 and is coordinated by the Inter-Agency Electronic Grants Committee (IAEGC). The goals of the Federal Commons Project are to present a single federal face to grantee organizations and to offer easy access to information about grant opportunities, single-grantee registration and profile features, and electronic communications and transactions for both pre- and post-award processing.

E-grants initiative—As one of the Bush Administration's e-government efforts, the Department of Health and Human Services is leading a multi-agency project to simplify and standardize fundamental parts of the grants work of all federal agencies. These efforts are bringing many federal agencies, research institutions, and state governments to the discussion table and involving many of them in demonstration and pilot projects to test new models.

State-based e-grants initiatives—A number of states, including Pennsylvania and New York, are leading the field in electronic grants initiatives. These states are investing heavily in the development and implementation of processes and systems to support grants making. Both states are active members of the Interstate Advisory Group, a group of states involved in e-grants initiatives, that advises the Federal IAEGC in its Federal Commons Efforts.

Research themes for the grants-supported research enterprise

- multiple value propositions
- enterprisewide workflows
- knowledge creation, capture, and management
- collaboration across boundaries
- effective use of information technology

Understanding the challenges

Moving toward the ideal research enterprise requires a solid understanding of these challenges and how best to respond to them. The new knowledge needed to build that understanding and to design effective responses is not likely to come from research in a single discipline or analytical model. We need instead wide-ranging and integrative efforts to help us understand how the research enterprise works today and how it can move towards an ideal future. These efforts can be organized around five themes that are reflected in the current work of and the challenges faced by the research enterprise as described on the next page:

- understanding the multiple value propositions that stakeholders bring to the enterprise and how they are aligned, are complementary, or conflict
- understanding how work is done by individuals and groups, within and across organizations
- understanding how individuals, groups, and organizations collaborate across the boundaries of structure, time, and place
- understanding how knowledge is captured, managed, and used within the enterprise
- understanding how to choose, use, manage, and support information technology investments

Chapter 3. Responding to the Challenges: A Thematic Research Agenda

The five themes introduced at the end of Chapter 2 frame an agenda for the research enterprise that reflects the concerns, insights, and experiences of a wide range of stakeholders. This chapter discusses the five themes and presents key research questions for each.

Understanding the multiple value propositions that stakeholders bring to the enterprise and how they are aligned, are complementary, or conflict

Value propositions and interests are central to the way stakeholders and decision makers participate in and attempt to influence the grants-making process. These value propositions involve different priorities given to knowledge building, ethical behavior, financial accountability, relevance to societal needs, and inclusiveness in decisions. The enterprise must be sensitive to where stakeholders agree about these values and where they do not. It must recognize where conflicts must be resolved, avoided, or accepted, and where consensus forms a foundation for action. Moreover, individual stakeholder groups are seldom homogeneous in their views or priorities, so research on value propositions should include attention to value differences both within and across the relevant organizations and stakeholder groups.

Grants-making policies and award decisions involve a wide range of potentially competing value propositions and interests. These include propositions about what rules and priorities should govern the grants-making process; what questions, institutions, disciplines, or styles of research should receive more or less funding; who should participate in review and allocation decisions; and who should decide grant policies and priorities. Exploring the dimensions of seemingly competing values, for example, is a strategy for discovering

real or perceived differences. Identifying and sharing these value propositions as part of joint problem solving can allow members of the enterprise to understand competing values in a multifaceted way. For example, in an effort to respond to its own need for budget accountability and grantee interest in budget flexibility, and a shared interest in reducing administrative burden NIH established a new policy that provides for budget blocks. NIH budgets are now submitted in blocks of \$25,000. Grantees report budget categories and aggregate amounts within those categories. Their policy enables the accountability that NIH is interested in, provides flexibility to grantees within budget categories, and frees both from the level of effort associated with line item budget preparation and review.

Better knowledge about stakeholder values and interests could also help us evaluate the benefits of research by identifying outcomes most highly valued by critical stakeholders. Better understanding of these interests and value propositions could also be useful in identifying the terms of discourse most likely to communicate effectively about the value of research to the range of relevant stakeholders. Information about the benefits of biomedical research, for example, can be framed to communicate effectively with patients and health care advocates, as well as with scientists or clinicians.

Key research questions

- What values are held by the different stakeholders within the research enterprise?
- How are these values operationalized?
- How do values influence decision making in the research enterprise?
- How do values influence the cost and performance of the enterprise?
- What policy and practice alternatives might move the enterprise close to the ideal vision?

Understanding how work is done by individuals, within and across groups, and within and across organizations

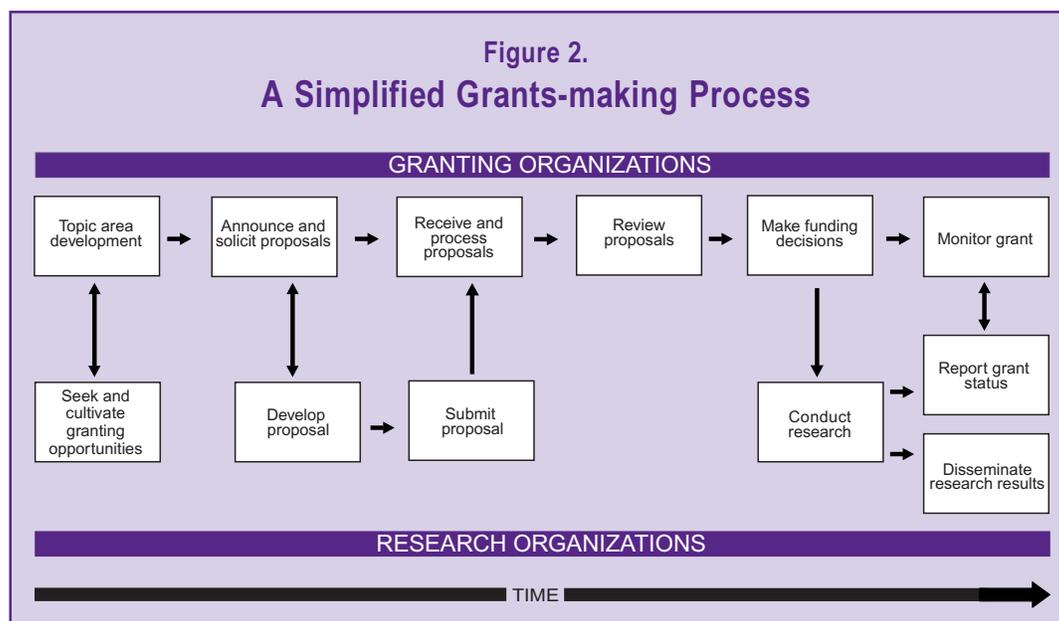
At its most basic level, grants making is a series of business processes made up of highly interdependent work flows. Many of these processes are performed in parallel, others play out in specific sequences. They range from very flexible to highly rigid. Some processes are carried out within single departments; others span multiple organizations across the enterprise. Understanding how work is done within and among the organizations in the enterprise is therefore a critical building block of the research agenda.

The essence of workflow is role-based routing that reflects complex organizational policies. The proposal preparation, submission, review, and management stages of the grants-making process (illustrated in highly simplified form in figure 2) are governed jointly by the policies and practices of many organizations. As the enterprise evolves from paper-based and

manual workflow systems to sophisticated electronic work-flow systems, we need increasingly detailed and comprehensive models of how work is done.

Workflow technologies deal with work processes as a collection of activities that support a specific business process. This overall business process is treated as consisting of two workflow components, both of which are critical to smooth and effective operation. These are control flow and data flow. The mechanisms and sequences of events that determine the path and pace of the work are known as the control flow. Some activities in a process can be performed in parallel, while others must be done in sequence, thus there are multiple paths or flows possible for a business process. Data flow refers to the movements of data and documents that accompany or make up each activity in a business process.

For workflow technologies to be effective in grants making they must meet several criteria. They must enable researchers to focus on the content of a proposal, reduce overall human effort, minimize the number of steps in a process, and minimize the time to process a proposal. Although many current



workflow systems meet some of the above criteria, none appears to address fully the complex interplay of organizational policies and interorganizational relationships involved in the grants-making process. Accordingly, future research should focus on the development of next generation workflow systems that include features such as a meta model or language for describing complex group activities and tasks. Further, they must capture complex organizational policies and handle the cross-organizational implications of policy or process changes. Research is also required to develop a framework for dynamic workflow schema changes that allow for changes to be made “on the fly” rather than necessitating wholesale upgrades or re-engineering of systems.

By its nature, the grants-making process is collaborative and hence needs to support collaboration tasks within and across organizations. Most current workflow technologies lack this support and therefore present another area for future research: the development of robust architecture and applications that facilitate seamless integration of interorganizational workflow and collaboration support systems.

Key research questions

- What is the nature of work conducted by the various individual stakeholders within the grants-supported research enterprise and what are the most effective ways to model and analyze these work processes?
- How does this work change when conducted in an interorganizational arena?
- How can modeling tools capture sophisticated interorganizational group processes?
- Can complex organizational and interorganizational policies be adequately described and used effectively within workflow systems?
- How can workflow technologies support dynamic workflow changes?
- What technical architectures support collaboration and what applications are needed to integrate workflow across interacting, but separate, organizations?

Understanding how knowledge is captured, managed, and used within the enterprise

The grants-making enterprise is both knowledge intensive and multi-organizational. Thus, improved intra- and inter-organizational knowledge creation, sharing, and management are critically important in enhancing effectiveness and supporting the ideal vision for grants-supported research. At present, no single discipline or research frame is adequate to study how knowledge is acquired, used, and shared. These frames include the social construction of knowledge and the sociology of science, organizational theory and organizational learning, the knowledge-based theory of organizations, and the technologies and methods known as knowledge management. While none of these is comprehensive, they do share some general concepts that are useful to describe and analyze the knowledge issues involved in the grants-making enterprise, they are:

- *explicit knowledge*—which can be expressed and communicated in formal ways (such as through language, symbols, or images)
- *tacit knowledge*—which is possessed and applied by a person but not fully expressed or communicated in formal terms
- *embedded knowledge*—which is expressed or captured in artifacts, groups, processes, or structures
- *knowing or knowledge-in-action*—which refers to knowledge that is part of and expressed or shared through practice or activity.

Developing, sharing, and managing these forms of knowledge requires distinctive strategies and methods that reflect the important differences among them. The formal grants-making processes are most appropriate for and are often supported by formal mechanisms for collecting and working with explicit knowledge about policies, regulations, scientific programs, proposals, investigators, institutions, and activities. However, there are several unanswered research questions regarding how best to handle these explicit knowledge assets. These include how to build or expand formal institutional memory and make it accessible and usable. Additional research is needed to explore what semantic and ontological resources or tools are needed to integrate explicit knowledge across programs and disciplines. This research should include attention to what forms of learning and which knowledge-sharing mechanisms are best suited to the social structures and cultures of grants-making organizations and to the various disciplines or practice communities within them.

Along with this substantial body of explicit knowledge, grants making requires subtle judgments and considerable tacit knowledge. In any grants-making organization, program staff have difficulty in delineating and codifying the tacit knowledge that is created and used in making complex judgments when working with investigators and reviewers. Research related to tacit knowledge should include attention to the kinds of tacit knowledge employed in seeking grants, in the scientific review process, and in grants management. It would also be useful to study the role of organizational factors, such as trust and communities of practice, on tacit knowledge sharing and management.

Even though it is not generally recognized, embedded knowledge plays an important part in much of the grants-making enterprise. Knowledge is embedded in review procedures, information systems, and in many of the group processes that are characteristic of the enterprise. It would be useful for research related to embedded knowledge to explore how knowledge about grants making

becomes embedded in organizational processes and cultures, and under what conditions or forms embedded knowledge acts as valuable institutional memory or as an impediment to innovation. The knowledge content of some activity may be formalized and explicit (e.g., how to solicit proposals) but others may be much less so (e.g., how to conduct a review panel, or how to evaluate the scientific merit of an idea).

Key research questions

- How can the knowledge embodied in the grants-supported research enterprise be usefully classified by type (explicit, tacit, embedded, knowledge-in-action)?
- How, or in what way, can the interplay among these types be modeled? By what means can one type be transformed to another (e.g., can tacit knowledge be made explicit)?
- What role do organizational factors, such as trust and communities of practice, have in tacit knowledge sharing and management?
- What semantic and ontological resources or tools are needed to integrate explicit knowledge across programs and disciplines?
- How do the dynamics of critical knowledge-in-action processes affect the outcomes of grants-making decisions?
- To what degree is participation in these processes necessary for developing the knowledge required by agency staff or investigators?
- How does knowledge about grants making become embedded in organizational processes and cultures, and under what conditions and in what forms does embedded knowledge act either as valuable institutional memory or as an impediment to innovation?
- To what degree is the unequal distribution of knowledge about grants making throughout the enterprise an impediment to the development of proposals or a source of unfairness in grants making?

- What sorts of policy or procedural changes would reduce or eliminate these problems?

Understanding how individuals, groups, and organizations collaborate across the boundaries of structure, time, and place

Grants making is a collaboration-intensive activity with collaborations in both the intra- and inter-organizational contexts. Since these activities cut across both time and space, collaborative technologies present attractive possibilities for improved communication and performance. Over the years, electronic mail, workflow, and virtual meeting technologies have been deployed by organizations to enhance the effectiveness of their collaboration tasks. When used appropriately, these collaborative technologies can foster creativity, improve the quality of discussions, save time, and be satisfying to use. However, determining what constitutes appropriate use of these technologies is a nontrivial undertaking. These technologies appear to be most helpful for groups that experience communication problems due to their size, for groups that handle complex problems or tasks, and for virtual teams with members located in different places, all of which are found in the grants-making process.

The grants-supported research enterprise presents several excellent opportunities for studying collaboration and collaboration tools. Each opportunity includes a range of collaboration activities focused on different aspects of the enterprise. The development and definition of research initiatives, for example, involve granting agencies, interested constituencies, potential investigators, and political leaders. Proposal preparation may involve investigators in different departments or different institutions. Proposal evaluation and selection often involves geographically distributed review panels.

Grants management involves collaboration among administrators and program officers in the granting agency along with research administrators and investigators in the grantee organizations. Successful deployment of collaboration technologies in grants making presents several research challenges. A salient feature of collaborative technologies is their ability to improve the exchange of both common and unique knowledge among the participants. However, mere exchange of knowledge does not enhance the quality of collaborative activity, which requires better understanding of the deeper structures and processes of collaboration. From a practical perspective, the challenge is to change the way people work by encouraging experimentation, enabling careful reflection and evaluation of ideas and action, adopting and inventing new best practices, and developing special purpose processes and tools. A related challenge is to identify best practices that can be extracted from one setting and adapted for use in others.

Too often organizations import beliefs and theories from the “old media” (i.e., paper-based work processes), and find that just automating the old ways does not bring significant benefit. New theories, new work processes, and new tools to reflect and inform emerging modes of group work are needed to advance collaboration initiatives and to guide the adoption of new work processes and structures engendered by technology use.

Key research questions

- What is the nature of the critical collaborative processes in current efforts to develop research initiatives, prepare and review proposals, conduct research, and manage grants?
- What are the key factors that lead to successful collaboration in the research enterprise? What tools and techniques need to be developed for virtual collaboration to be successful?

- What kinds of incentives support collaborative work models? How can organizations provide incentives for collaboration?
- What advances are needed in technologies such as peer-to-peer networking?
- How do these technologies interact with group norms and functioning to produce effective collaboration?

Understanding how to choose, use, manage, and support information technology investments

Modern organizations cannot operate without significant investments in information technology to support both routine operations and new innovations. However, the constantly changing aspect of technology and the risks of innovation pose dilemmas for organizations. All innovations have risks resulting from the interactions among innovation characteristics and organizational characteristics. Insufficient knowledge and understanding of these interactions leads to uncertainty about consequences, thus generating significant organizational and operational risks.

In IT applications, poor risk management often leads to failure. Recent research indicates that 50 to 80 percent of IT initiatives in both the public and private sectors fail completely or produce unsatisfactory results. Some of the risk factors that lead to such failures include misidentifying the problem, underestimating complexity, instituting inadequate controls and monitoring, a lack of champions and sponsors, overvaluing novelty, and unstable environments.

Some factors that contribute to the failure of IT projects are unique to public sector organizations. Unlike private sector firms, for

example, public agencies are accountable to many more stakeholders who pursue divergent objectives, rather than a shared bottom line. This engenders problems in project valuation and measurement of effectiveness. In addition, the structural characteristics of a public agency that limit the discretion of any one decision maker may also limit the ability to act quickly or creatively prevent project failures.

Regardless of the growing body of descriptive, theoretical, and practical knowledge about information technology, practitioners seem unable to sense early failure symptoms or even to avoid well-known shortcuts to failure. The deeper causes of failure appear to be only partially known. A variety of new and emerging frameworks are moving away from the past dependence on purely technical models and introducing models that incorporate more social, behavioral, and organizational factors for understanding information technologies and their application and use in organizations. All of these factors are significant in systems that support the work of individual organizations, but they increase in importance—and difficulty—when systems must connect multiple organizations across time, geography, and functional roles.

Information technology selection, use, and management affect nearly every activity and responsibility in grants making. IT supports communication about research initiatives and opportunities to propose projects. Investigators use IT to communicate with program officers and each other in the process of developing proposals. IT is used to support the proposal review and selection process and to identify and manage subsequent awards. Investigators use IT to help support the research process and to communicate results. Sometimes separate systems are used for different activities. Some systems, such as the National Science Foundation's FastLane, incorporate many functions into a more comprehensive system.

Key research questions

- What are the salient predictors of success and failure in IT applications in organizations and how can they be made visible and actionable?
- How can organizations involved in grants-supported research best collaborate on the conceptualization, design, and testing of shared information systems?
- How should the costs of shared information systems be distributed across multiple organizations?
- What return-on-investment models are suitable for multi-organizational systems?
- What IT investment strategies allow both stable current operations and reasonably quick adoption of new tools to improve performance?

Chapter 4. Responding to the Challenges: An Integrative Research Agenda

While each theme in the previous chapter suggests important research questions of its own, a different set of questions emerges from a more holistic look at the research enterprise. These questions serve to highlight the interdependencies among the research themes. They might be thought of as integrative questions, or goals, that span the thematic areas and move us toward practical applications.

For example, a research project designed to identify new models of the grants process must look at the research from the perspective of value; what do the stakeholders value and how do they attribute value to what they and others contribute? It must examine the flow of work through groups and organizations and explore how knowledge is or could be captured, managed, and shared. Such a project must

Integrative Research Goals and Cross-Cutting Investigative Themes					
Selected Integrative Research Goals	Investigative Themes				
	Value	Workflow	Knowledge Sharing	Collaboration	Effective use of IT
New ways to identify and define the substantive goals of research initiatives	✓		✓	✓	
New models of the grants-supported research process that make different assumptions about roles, relationships, and responsibilities	✓	✓	✓	✓	✓
Alternative strategies and new technologies to support the review and selection of research proposals	✓	✓		✓	✓
Incentives for collaboration across disciplines, roles, and organizations	✓	✓	✓	✓	
New technologies for multimedia proposal, development, submission, and management	✓	✓	✓		✓
Information-centric processes as a tool for an enterprisewide orientation	✓	✓	✓	✓	

also investigate the role and use of collaboration. New technologies to support grants making would also need attention and demand credible and comprehensive models of the enterprise and its component parts, including an understanding of the dependencies between work processes and system design. This chapter presents some of these integrative research goals.

New ways to identify and define the substantive goals of research initiatives

The research enterprise is continuously cultivating the next generation of questions that will advance science. This entails decisions about which research topics to invest in today balanced with decisions about what initiatives to create for tomorrow. This requires that information and ideas flow freely within the enterprise and that processes exist to ensure their full consideration. Research on this topic could generate and test benchmarks for evaluating existing approaches to generating initiatives. Such research might include a comparative analysis of current practices for identifying topics, criteria for judging the success of the process, or an evaluation of the implementation of initiatives originating from different sources. It might also address the potential of new Web technologies for collaborating on the definition and selection of new initiatives.

New models of the grants-supported research process that make different assumptions about roles, relationships, and responsibilities of the various players

Web-based tools to support grants submission, review processes, and administration are under development at many organizations within the research

enterprise. The motivations for these efforts range from responses to accountability and efficiency pressures, to legislative mandates, to the need to replace outdated systems. All of these efforts include the range of organizational and technical challenges associated with enterprisewide initiatives. This research could examine alternative models of the grant proposal, submission, review, award, and management process, including the technology and organizational design implications of these models. It might demonstrate how different technical capabilities support widely different conceptualizations of the entire process. For example, the Web makes it technically possible for the research institution, not the granting agency, to retain custody of research proposals while giving program officers and reviewers electronic access. The challenges related to such a model could be identified and examined in terms of organizational, technical, process, and policy implications. In our Web example, authenticity, security, and electronic records management are just three of the issues that must be examined.

Alternative strategies and new technologies to support the review and selection of research proposals

Traditionally, technology has played a role in supporting the review process. The potential of technology to go beyond its primary role as a document delivery mechanism in the review process is great, but relatively unexplored. This research could start by mapping the various proposal review models in use. The research could identify and document these different review processes and draw out and make explicit the underlying assumptions and values for each. The results could inform the development of new strategies, new support technologies, and improve our understanding of the factors that influence success. Research is needed to meet the challenges of characterizing proposals effectively, of characterizing the

skills of potential reviewers, and of using this information to quickly match reviewers to proposals. This should be studied from multiple perspectives such as knowledge sharing and natural language processing. Such a study might also identify cultural differences across communities of reviewers with respect to what constitutes a good review, a good review process, and evidence of fairness. Research could also explore how different technologies, different presentations of information, and different structures might work at various points in the process.

Whether an organization uses a peer review process, or depends more on program officer expertise, program officers are central players in the review and selection of research proposals. They depend heavily on proposal-based information and expert knowledge to move a review process forward. Research that focuses on their role and on the information flow and human interaction it requires might generate new understanding of the nature of that work, its interpersonal and organizational dynamics, and how these influence technology requirements, business processes, and overall performance.

The specific nature of the workflow, collaboration, and knowledge sharing could be identified through this analysis and used to inform the development of relevant technologies. The role of emerging technologies such as peer-to-peer networks, for example, could be examined in the context of the review process. Applications of emerging collaboration technologies could be examined, with the results informing both current and future technology development.

Incentives for collaboration across disciplines, roles, and organizations

This research might focus on defining needed collaborations and the incentives and disincentives that exist across

disciplines, universities, and agencies within the grants making enterprise. It might aim to uncover which incentives work under what conditions by examining community norms, interpersonal and organizational networks, theories of self interest and mutual interest, social exchange, proximity, shared electronic resources and facilities, physical environment, monetary incentives, or economies of scale.

This research could look at current models of group communication and operations to identify their strengths and weaknesses. The insufficiencies of these models represent a fundamental research challenge—modeling group operations for the purpose of basic understanding about how groups really work. Armed with this knowledge, we could then begin to build incentives and tools that truly support group processes.

New technologies for multimedia proposal development, submission, and management

The tools used to conduct research and to represent findings are changing. High density images, sound, video, animations, and 3-D renderings, for example, are becoming more commonplace as tools to represent research findings. The ability of the enterprise to effectively bring this information to bear on funding decisions rests heavily on the development of technologies to support the incorporation of multimedia resources into the proposal development, submission, and management process. In many cases, however, the advanced techniques used to create, manage, and present findings cannot be demonstrated or shared within research reports to funding agencies or in follow-on proposals. The tools available to researchers to incorporate multimedia into traditional proposal structures and the capacity of granting agencies to accept proposals with multimedia components are limited.

Information-centric processes as a tool for an enterprisewide orientation

Understanding how information is used within the research enterprise and how it flows among the participants would allow us to view information as an enterprisewide resource. Mapping the similarities and differences among the participants and exploring how particular types of information are used or not used across the enterprise could provide new insights into organizational design and system design.

An enterprisewide view of how information is created, changed, received, managed, accessed, maintained, and destroyed over time would also provide insights into the development and implementation of enterprisewide strategies for capturing, building, and managing knowledge. Understanding how information is exchanged, flows through, and is acted on by the various entities within the enterprise may suggest new strategies to facilitate this process and to examine the potential benefits of an information-centric view.

Chapter 5. Toward the Ideal Research Enterprise: Action Recommendations

We offer the following recommendations to stimulate and inform discussions about action that can begin today to move the research enterprise toward the ideal state. Together with the research agenda, these recommendations comprise a balanced strategy for building future knowledge while acting on today's promising ideas.

Document and evaluate different models and philosophies of grants making

Like all other federal agencies, granting agencies are expected to measure program achievements and process outcomes. An important debate is occurring about what constitutes useful measures of performance for long-term research investments. However, a somewhat easier and very valuable evaluation task could be undertaken today to help us document and better understand the variety of program models in use by different agencies. Comparative assessments of such elements as cost to all participants, openness, time factors, and predictability across the various models now in use would be very informative for all granting agencies. While each agency is well-versed in its own processes and traditions, few are more than generally aware of the strengths and weaknesses of other approaches that they might try. For example, different federal agencies use different strategies for proposal solicitation, review, and selection. A formal evaluation of these strategies and their strengths and weaknesses might foster their appropriate application in new venues, or might improve them through critical review by peers. The challenges of establishing practical comparative metrics and data sources are not trivial, but the learning potential of this kind of evaluation is great.

Support and improve communication across research and administrative professions within the enterprise

One mechanism for carrying out this recommendation would be an annual conference to support knowledge sharing and idea development between and among practitioners and researchers. Such an event would provide a regular forum for knowledge sharing among all the stakeholders in the enterprise. Papers could be invited from program managers and administrators that describe planned projects, new initiatives, and opportunities for and impediments to progress. The research community could be invited to report on findings applicable to grants making organizations from areas such as information technology, sociology, information science, and management studies. The conference format would be designed to maximize cross-professional knowledge sharing, to identify overlapping interests, and to foster collaborative research and problem-solving initiatives.

Identify and share best practices in communicating within the enterprise and with the public about science

Communicating effectively about the results and benefits of research is critical to ensuring that the White House, Congress, other governmental organizations, the private sector, and citizens understand the value of grant-supported research. The challenge, as with any communication effort, is to explicitly address the interests of separate and sometimes overlapping audiences. The media and content that are

suitable for communicating among scientists are not effective for other audiences such as elected officials and staff, the press, or the public. Members of the research enterprise, especially the grants-making agencies, should identify, evaluate, and disseminate information about communication methods, programs, and messages that successfully engage the interest of these different audiences.

Continue to invest in the development, deployment, and adoption of standards for common data, tools, and activities

The early work of the Federal Demonstration Partnership focused on standard rules for grants management. This standards-based strategy still holds great promise for improving the enterprise. By collaboratively selecting and deploying standards, the many stakeholders in the enterprise stand to benefit both individually and collectively. Standard vocabulary, work-process models, data definitions and formats, records requirements, and basic technical tools are just a few of the areas where there is both great need for standards and great potential benefits from adopting them.

Experiment with business models that reflect different assumptions about institutional relationships

A large percentage of the funding from some of the larger granting organizations goes to a very small number of organizations. For example, 80 percent of the research dollars distributed by NSF goes to 150 organizations. Business-to-business relationships between granting organizations and the universities and other research facilities they support therefore offer great opportunities to improve the efficiency and accountability of proposals

submissions and grants management. Private sector supply chain and e-commerce models, and government-to-government (G to G) and government-to-business (G to B) electronic government models all present possible improvements in these crucial business relationships. Instead of treating each grant as if it were a new business relationship, these models would treat each grant as a defined transaction within an already established business relationship. This business relationship could capitalize on the capabilities of each participating organization and offer substantial economies of scale. Granting organizations, research institutions, investigators, and taxpayers would all benefit from experiments along these lines.

Continue to experiment with virtual collaboration work models and technologies

The research enterprise is highly dependent on collaboration. Initiative development and institutionalization requires collaboration among a wide range of stakeholders, including scientists, program directors, grants-making organizations, university research administrators, and Congress. Developing and distributing program descriptions, cultivating research proposals, and all of the other steps in solicitation, selection, and grants management require collaboration. For many, significant participation in the enterprise will increasingly be possible only through virtual collaboration. While more research and better tools are clearly needed, conference calls, teleconferences, and virtual workspaces already provide some opportunity to extend participation. Thoughtful, evaluative use of these basic collaboration technologies will not only inform their further development, it can also deliver value to the enterprise today.

Coordinate announcements of focus areas across the enterprise

Very often multiple granting agencies seek proposals in overlapping or tightly related areas. For example, many agencies are funding work in bioterrorism, collaborative technologies, and digital libraries. Currently, the burden for identifying agencies seeking to fund research in a particular area falls to the individual researcher or institution. Providing mechanisms for agencies to post announcements and grant descriptions collectively by topic or issue would streamline the researcher's effort to identify and compare the opportunities most relevant to his or her work. Reducing the burden of this process for researchers enables them to devote more effort to the development of sound and successful proposals and to conducting the research itself. Implementation of tools and strategies to support this kind of coordination is underway in programs like the Federal Commons, but additional efforts to cultivate an enterprisewide approach to program announcements is still needed.

Identify and apply the knowledge gained through funded research to the needs of the research enterprise itself

New knowledge created by federally funded research is, in many cases, highly relevant to the achievement of the ideal research enterprise. Research findings in organizational behavior, decision making, risk assessment, information technology, digital libraries, information preservation, economics, interpersonal and interorganizational relations, and other topics may all pertain. To take advantage of this rich array of knowledge, the enterprise must actively seek it out and invest in efforts to select and apply it to its own further development. In the spirit of the old story, the shoemaker's children deserve shoes.

Appendices

1. Participants
2. Methodology

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- Joyce Evans**, Division of Elementary, Secondary, and Informal Education, NSF
- George Fertig**, Ford Foundation
- Richard Foster**, W.K. Kellogg Foundation
- Timothy Gage**, Anthropology Department, University at Albany, SUNY
- David Garver**, eGrants Best Practices
- Geoffrey Grant**, Research Administration, Stanford University
- Mark Green**, National Institute on Drug Abuse, NIH
- Irene Grissom**, National Center for Research Resources, NIH
- John Grzechowiak**, Division of Grants and Agreements, NSF
- Marcia Hahn**, National Institute of Allergy and Infectious Diseases, NIH
- Steve Hausman**, National Institute of Arthritis and Musculoskeletal Skin Diseases, NIH
- Charles Havekost**, U.S. Department of Health and Human Services
- Sharon Hays**, U.S. House of Representatives
- Rona Smyth Henry**, Robert Wood Johnson Foundation
- Hortencia Hornbeak**, National Institute of Allergy and Infectious Diseases, NIH
- Cheryl-Lee Howard**, University Research Projects Administration, Johns Hopkins University
- Philip Ianna**, Division of Astronomical Sciences, NSF
- Eric Itsweire**, Division of Ocean Sciences, NSF
- Katrina Jocktane**, Center for Information Technology, NIH
- Paul Johnson**, National Institute of Child Health and Human Development, NIH
- John P. Keating**, Chancellor, University of Wisconsin-Parkside
- Janice Kehn**, Purchasing Department, University at Albany, SUNY
- Bradley Keister**, Division of Physics, NSF
- Susan Kemnitzer**, Division of Engineering Education Centers, NSF
- Elaine Kranich**, Ford Foundation
- Akhil Kumar**, Leeds School of Business, University of Colorado at Boulder
- Kathleen Larmett**, National Council of University Research Administrators

Robert Long, W.K. Kellogg Foundation

Jane Isaacs Lowe, Robert Wood Johnson Foundation

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Jeryl Mumpower, Office of the Provost and Vice President for Academic Affairs, University at Albany, SUNY

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Charles Paoletti, Office of Naval Research

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Everett Sinnott, Center for Scientific Review, NIH

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Francis Wodarczyk, Division of Chemistry, NSF

Trudy Wood, Office of Procurement and Assistance Policy, Department of Energy

Daniel Wulff, Biological Sciences, University at Albany, SUNY

Richard Zitomer, Biological Sciences, University at Albany, SUNY

Methodology

This report is the result of a one-year effort to understand the research enterprise in the United States and the world of possibilities for its future. In particular, the study sought to re-envision the proposal and grant management functions in government organizations that award research grants, and to explore how process changes and advanced information technologies could support that transformation. The Center for Technology in Government conducted this research in cooperation with the National Science Foundation and the National Institutes of Health.

Best and Current Practices Research

Document and Web Search

Purpose: To provide background information on public and private large-scale research grants-making organizations, and to explore best practices for comparison with interview data and for later consideration of potentially useful innovations.

Procedures: This work involved searching both paper documents and Web sites for information on: the agencies central to this research project; the legislative and larger federal environment in which they work; other federal grants-making agencies; private for-profit and nonprofit organizations involved in funding research; and organizational and technological innovations relevant to this enterprise.

Results: This information gathering resulted in short reports regarding: agency and foundation profiles; the Federal Commons Project, Electronic Research Administration (ERA), the Inter-Agency Electronic Grants Committee (IAEGC); organizational issues and innovations; technology issues and innovations; and experiences with innovations.

Interviews

Purpose: To hear about grants making in very large organizations, and about the challenges, opportunities for improvement and growth, and visions for such organizations from various perspectives within the grants-making community.

Procedures: In-depth, unstructured interviews were generally conducted in person with two researchers and were recorded using audiotapes and fieldnotes. Interviews were held at the interviewees' institution and involved both groups and individuals. After September 11, the researchers successfully used video-conferencing technology to approximate the in-person process. Interviews were organized in three groups, including: 19 NSF and 20 NIH senior staff involved in different aspects of the granting process; 16 senior staff from other granting organizations, both private and public, selected by size and by nature of grant provision as comparable to NSF/NIH; and 17 university faculty, and staff experienced in NSF and/or NIH grants processes as proposers, grantees, reviewers, program officers, and/or administrators. Participants were asked to: describe the work they do as part of the research enterprise; assess the extent to which technology is already integrated into that work; consider the organizational and individual value embedded in that work; and suggest improvements that would help develop the ideal granting agency of the future.

Result: Interviewees' experiences and suggestions for broad-scale change were used, along with other best practices data, to develop descriptions of ideal characteristics of a granting agency of the future and a draft vision of such an organization. These were presented back to NSF and NIH interviewees at the December 2001 Workshop for critical feedback.

Workshops

December 2001 Workshop, Washington, D.C.

Purpose: To identify the relative importance of ideals drawn from the interview data and to clarify what steps toward developing these ideals were feasible with the help of further research.

Procedure: The first workshop involved 18 participants drawn from NSF and NIH interviewees. Framed by “a draft vision of an ideal government granting organization,” the workshop comprised presentations and large- and small-group discussions on beneficiaries, barriers and enablers in the areas of strategy, political relationships, stakeholder relationships, organization, processes, and information technology.

Result: Participants prioritized characteristics in terms of importance and “doability.” Themes for a future research agenda emerged from discussions of those considered most important but in need of further research in order to become feasible.

March 2002 Workshop, Arlington, Va.

Purpose: To refine the vision; to discuss the challenges regarding value, workflow, knowledge, collaboration, and technology; and to recommend a research agenda that addresses them.

Procedure: The second workshop involved 37 participants from a range of federal agencies, private foundations, universities, and related professional associations. The workshop began with a panel discussion on what we value in the research enterprise, followed by a series of expert presentations from invited speakers and small-group discussions on: relevant organizational, policy, and technology initiatives; emergent streams of research; and what actions and knowledge are needed to achieve the ideal.

Result: This workshop took the vision from the level of ideal granting agency to ideal research enterprise. The data gathered in the workshop, together with earlier findings and expert knowledge, were used to formulate recommendations about what must be done in the research enterprise to achieve the vision. These are presented in the body of this report.